# Towards Motivation Modelling within A Computer Game Based Learning Environment: An Empirical Study

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# Abstract

This thesis addresses the issue as to how to model a student's motivation when using a learning environment. Currently, this is considered as an important topic since a) motivation is regarded as key to successful learning by educationalists, b) those building computer-based learning environments are attempting to design in features that will assist in motivating learners while using their systems, c) researchers in the areas of intelligent learning environments (ILEs) and intelligent tutoring systems (ITSs) are looking for methods to detect a student's motivation during their interaction with an adaptive system, and d) researchers in ITSs are looking for strategies that a learning environment could use to motivate a student or to scaffold his/her motivation. A well-founded model that partially explains the way in which motivation changes during an interaction with an ILE is potentially very valuable to these different goals. In particular, the model should prove to be of great benefit when creating learning environments that take into account the motivational aspects of the learners since it represents the process of how they are motivated through the use of an ILE.

In this thesis the focus is on the construction of a learner's motivational structure for an ILE grounded in the context of an educational game. The thesis reports the development of a qualitative model of the motivation of learners during their interaction with the ILE. One of the main issues is the specification of the context as the motivational structure of learners cannot be assumed to be the same in different contexts. A preliminary causal model showing the relationships between a learner's motivational characteristics and features of the ILE was developed. Two computer-based research instruments were then built: a game prototype aiming to teach some concepts in databases (Alex's Adventure) and a computer program (MoRes).

Alex's Adventure was developed in such a way that it included all features of the ILE presented in the model whereas the other parts of the model were implemented through MoRes. Six detailed case studies were performed in order to validate the preliminary model. The validation resulted in changes to the preliminary model which are believed to produce an improved model. The analysis also resulted in a number of key points and condition–action rules which are considered to be of use for the implementation of future adaptive computer systems that could manage and support learners.

The thesis makes an original contribution to the Artificial Intelligence in Education (AIED) community, particularly in terms of the method of case study analysis and the new model of motivation.

# Table of Contents

# List of Tables

**F. The Analysis of Case Study 5**



**G. Checklist Matrix on Facial Expressions and Gestures**

# List of Figures

# Acknowledgement

*Gratitude is the memory of the heart. ~Jean Baptiste Massieu, translated from French*

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# Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

*(Jutima Methaneethorn)*

# Chapter 1

# Introduction

## 1.1 Research Proposal

Learning can be regarded as a fundamental part of human life and is an aspect that we all spend enormous time on. The importance of learning has long been recognised not only by educationists, but also researchers from various disciplines (e.g. education, cognitive science, psychology, computer science, etc.). They seek ways to improve the learning and teaching process in order to encourage students to learn. Computer technology has played a growing part in the process. It is regarded to have the potential capability of transforming the process of education (Brown, 1985; Kay, 1977; Papert, 1980; Simon, 1983; Suppes, 1966, cited in (Lepper & Chabay, 1988)). The computer can serve a variety of purposes in relation to education. For example, it can be used as a tool for serving a simple goal such as facilitating the performance of routine tasks (e.g. word processing, data analysis, etc.) or it can be used as a device aiming to achieve a more complicated goal such as creating and presenting complex simulations and rich exploratory-learning environments. Over several decades many attempts have been made to exploit the powerful characteristics of the computer. These attempts have focused on the cognitive aspects involved in learning and instruction rather than motivational or social aspects of learning such as collaboration. Recent literature speculates that the motivational aspect also plays an important role in successful learning as well as the cognitive aspect (e.g. Pintrich, 1988; Pintrich & Schrauben, 1992; Pintrich et al., 1993). Even in the studies conducted in the classroom context, the results indicate that student interest and affect rank high in importance to teachers (Clark & Peterson, 1986; Clark & Yinger, 1979, cited in (Lepper & Chabay, 1988)). Reports on school-tutoring programs also deal widely with the issues of affect and emphasise on the motivational aspects such as goals and strategies for enhancing motivation (e.g. Koskinen & Wilson, 1982; Moore & Poppino, 1983, cited in (Lepper & Chabay, 1988)). The preliminary observations of tutors and analyses of tutoring-session transcripts conducted by Lepper & Chabay (1985) also suggested that one among several important components in tutoring strategies is motivation and human tutors' reactions are likely to be based on their sense of a student's feelings as well as their assessment of the student's knowledge and skills. Furthermore, as Bruner (1966) put in his book *Toward a Theory of Instruction*, "The will to learn is an intrinsic motive, one that finds its source and its reward in its own exercise." (p. 127). According to Bruner, it seems that the concept of motivation is one of the key answers towards the question of how to encourage the students to learn for their own sake.

Due to the fact that motivation has been regarded as one of the major components that contribute to successful learning, there has been an increasing amount of research interest that tries to integrate motivation into computer-based instructions; these attempts have been carried out in various contexts ranging from general computer-based instructions (e.g. Keller, 1983) to those that were developed for use in specific contexts such as interactive and intelligent learning environments (e.g. Malone & Lepper, 1987; Lepper et al., 1993; del Soldato & du Boulay, 1995; de Vicente, 2003). Research done in the interactive context focuses on the creation of the learning environments that are likely to be motivating for students (e.g. Waraich, 2002; Robertson & Good, 2003; Chen et al., 2005). On the other hand, research done in the intelligent context focuses on techniques or strategies in detecting/diagnosing learners' motivational states during an interaction with a learning environment and trying to adapt instructional materials in response to those states (e.g. del Soldato & du Boulay, 1995; de Vicente, 2003). It was considered that, indeed, both kinds of research have made obvious contributions to learning and the latter kind has thrown some light into the issue of creating learning environments that have the capacity to empathise with learners (known as 'empathetic' tutors (Lepper & Chabay, 1988)). However, the focal point of these research studies is the 'state' that was believed to lend motivation rather than the 'process' of how motivation occurs. As a result, there seems to be an issue which has not been addressed by the research described so far – the issue of how learners are motivated during the interaction with a learning environment. It was considered that research into this matter could reveal the mystery aspect of motivation in learning.

This thesis chose to research the construction of a learner's motivational structure while interacting with a computer-based learning environment in a specific context. The reason for which a context needs to be specified is that a motivational structure may be varied from one context to another. For example, the structure of learner's motivation during an interaction with an online learning environment may not be the same as that in the multimedia learning environment. Hence, our main research questions upon which this thesis is centred are:

1. Given a specific context for a learning environment, can we determine a motivational structure for learners during their interaction?
2. Can we make progress in determining the way this might change during the interaction?

We narrowed down our attention to the educational game context as we considered the context as being able to lend motivation. From the literature, learning environments developed within this context (known as game-based learning environments) are likely to have a strong impact on learners' motivation. (more details on the literature will be explained in chapter 3). We decided to investigate and to model the relationship between features of a game-based learning environment (which will be called ILE[1] features[2] through the rest of the thesis) and a learner's motivational characteristics[3] as we considered that there are strong relationships between them. We believe that such a model will be potentially of great benefit when creating learning environments that take into account the motivational aspects of the learners as the model represents the process of how one is motivated through the use of an ILE. In addition, the model will contribute to research in the contexts of both interactive and intelligent learning environments.

A qualitative approach was considered to be used when modelling motivation. The motivation for applying the qualitative modelling approach to model motivation of learners stems from our consideration of motivation as a dynamic and complex system which is difficult to inspect. The qualitative approach can be used as a tool for building conceptual models of complex systems, grounding explanations on explicit representations of the causal influences, testing different hypotheses and complementing numerical models (Miles & Huberman, 1994). From the literature, one technique used for modelling affective states of learners is based on Bayesian approach (see (Conati & Zhou, 2002) as an example). However, using the Bayesian approach can produce a numerical probabilistic model, but it cannot easily provide information about the

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[1] The term 'ILE' in this thesis refers to both interactive and intelligent learning environments since the research was done within the context of educational games in which obviously, it can be categorised as a kind of interactive learning environments. Some games contain an ability in adjusting some of their characteristics based on learners' preferences and this type of game can be classified as intelligent learning environments.

[2] The term 'ILE features' in this thesis is defined as the basic elements that make up an ILE.

[3] The term 'motivational characteristics' in this thesis is defined as motivational variables of learners which can be placed into two categories: trait (permanent characteristics) and state (transient characteristics) (adopted from de Vicente & Pain's (2002) motivation model).

dynamics of the learners' motivation. We are interested in providing a better cognitive account of what is going on when learners are motivated, so we can seek to manipulate that in a sound ethical and pedagogical manner. From our point of view, there are methodological advantages in developing a qualitative model before a quantitative one.

## 1.2 Research Goals

As mentioned earlier, the focus of this thesis is to reveal the process of how learners are motivated when interacting with an ILE built in a specific context. Thus, the main five research objectives are:

1. To investigate the relationships between learners' motivational characteristics and features of a game-based ILE in the context of educational games
2. To create a preliminary model of motivation based on existing literature.
3. To build the computer-based research instruments used for extracting motivational data from students. Two instruments were developed to serve this purpose: an educational game – Alex's Adventure – aiming to teach some concepts in Entity Relationship Modelling (ERM) domain, and a computer program – MoRes – which implemented the preliminary model
4. To seek an appropriate way in evaluating the preliminary model.
5. To construct the final model of motivation.

## 1.3 The Main Contributions of the Research

Since this research draws from a number of different disciplines and applies techniques used in both the area of computing and education, it has the potentiality to contribute to more than one research area. In particular, given that the model of motivation is the major outcome of the research and was drawn based on motivational research in computer-based instruction, specifically interactive learning environments and intelligent tutoring systems, and empirical evidence from the case study analysis, the research presented here is intended to be of value to the designers of interactive and intelligent learning environments who aim at exploiting the educational and psychological power in learning and teaching process. Furthermore, the model may be of value to educational theorists who seek strategies to enhance students' motivation; they may use the model as a roadmap to find a suitable way in manipulating the motivational variables in a sound ethical and pedagogical manner. Finally, given that the model deals with the aspect of motivational structure in a learning context and it exposes the hidden relationships among various motivational variables, cognitive scientists/psychologists may find the model useful for further investigation about other variables that are likely to contribute to motivation in learning.

To sum up, the current thesis contributes to the existing relevant research in four ways:

1. Based on the qualitative analysis of motivational data, the model of learners' motivation was developed and was considered to be of use to researchers from various disciplines as explained earlier. The novelty of the model is (a) that it demonstrates the existing relationships between the features of an ILE and the motivational characteristics of learners (b) that it relies on both specific theories of motivation in instructional design and empirical evidence (c) that it is created using a qualitative method in education – case study analysis in particular (d) that it can be applied to a specific context (the educational game context) and it may be extended to apply within other contexts.
2. Also, based on the results from the analysis, the condition-action rules[4] were produced. The benefits of the rules are that they represent the findings of the study in a symbolic manner which in my view (in the role of a computer programmer) is easier to understand and of use to the implementation of the rules in a computer software. Furthermore, the rules were considered to be of use as a stepping stone into the development of interactive and intelligent learning environments that can empathise with learners.
3. The method of case study analysis can also be considered as another contribution of this research to the AIED (Artificial Intelligence in Education) community. We exploited the potential power of this method to help us in getting an in-depth understanding of how a learner is motivated through the use of an ILE developed in a specific context; in other words, the method helps us in revealing the process of how motivation can be influenced to occur. The method is also used and suggested by researchers whose research relates to computing, education and affect (e.g. Alsmeyer et al., 2007). However, there are indeed a few concerns regarding conducting case studies (e.g. time-consuming). We argue that every method has its own flaws, but it also has its own strengths. Based on a review of literature (e.g. Yin,

[4] The term 'condition-action rule' (or production rule) is the device for representing human knowledge in the form of IF..THEN grammar. The term is commonly used in the area of expert systems which is a computer system intended to perform at the level of a human expert in a particular domain.

1994) the case study is a promising method that investigates a phenomenon within its real-life context; it relies on multiple sources of evidence and benefits from the prior development of theoretical propositions. Thus, we considered that the model of learners' motivation developed based on this technique is more valid and reliable.

4. Following the model proposed for the design and development of computer-based learning environments that are founded on computer games, a prototype game-based ILE aiming to teach some abstract concepts in the ERM domain was created as a learning environment that could strongly impact students' motivation. Also, following the preliminary version of motivation model developed on a theoretical basis (this will appear in chapter 4), the model was implemented into a prototypical computer program named MoRes. One may consider extending the prototype game-based ILE by including other concepts in ERM into the game. Similarly, one may consider using MoRes as an example to implement the revised version of motivation model into a computer software.

## 1.4 The Structure of the Thesis

The other chapters of the thesis are structured as follows:

**Chapter 2** presents a review of the relevant literature. It discusses the connection between learning, motivation and cognition, more specifically motivation and self-regulation in learning. The key theories of motivation used in this research are addressed and examples of research dealing with motivation are illustrated. Also, the issue of Affective Computing is reviewed briefly as it can be regarded as a related research area, but it is beyond the scope of this research.

**Chapter 3** also presents the review of the relevant literature, but it focuses on the association between computer games, narrative and motivation, particularly the aspect of how computer games and narrative contribute to learning and motivation.

**Chapter 4** sketches out the preliminary version of the motivation model along with an explanation of how the model is obtained.

**Chapter 5** describes the design and implementation of computer based research instruments to be used in the field study in order to collect the required data.

**Chapter 6** describes the design of the study. It explains issues such as the materials to be used in the study, the selection of the participants of the study and the description and justification of the methodology selected for the study. We also discuss the methodology of the data analysis (case study analysis) in this chapter.

**Chapter 7** In this chapter the results from the analysis of six case studies are presented.

**Chapter 8** In this chapter the revised version of motivation model is demonstrated. We also discuss some key points drawn from the case study analysis. Some condition-action rules derived from the analysis are presented.

**Chapter 9** presents the final conclusions of this research. It also discusses the limitations of the revised motivation model and it suggests possible further work that can be pursued in relation to the work presented in this thesis.

# Chapter 2

# Motivation and Learning Environments

## 2.1 Introduction

The importance of promoting students' positive emotions and keeping them motivated during the learning process has long been recognised. As Goleman (1996) states,

> "The extent to which emotional upsets can interfere with mental life is no news to teachers. Students who are anxious, angry or depressed don't learn; people who are caught in these states do not take in information efficiently or deal with it well." (p. 78).

According to Goleman, there seems to exist a relationship between emotion and learning; also, it is often suggested that positive emotions are a precursor to motivation (e.g. de Vicente, 2003). Students who have positive emotions (e.g. joy, happiness, etc.) are likely to learn better and tend to be active learners who attempt to learn for their own sake. Due to the major role of motivation in learning, there has been an increase in the amount of research in various disciplines (e.g. web-based learning (e.g. Pearce et al., 2005.), interactive learning environments (e.g. Waraich, 2002), intelligent tutoring systems (e.g. Rebolledo-Mendez et al., 2005; 2006) that seek to deal with the issue of motivation. The research ranges from attempts aiming at creating systems/learning environments that are claimed to be motivating for students to attempts trying to find the correct approach to motivate the students to learn.

In this chapter we provide a broad overview regarding theories of motivation based on the work of some motivation theorists. We also present a plausible connection between cognition, motivation and learning, specifically self-regulation in learning as this kind of learning is the most relevant to the context of this research. Then, we explain the motivation theories used as the core of this research. Next, we describe research that tries to integrate motivation and computing in an attempt at building tutoring systems that can empathise with students. We also review the issue of affective computing briefly at the end of the chapter as it was considered to be a related area of research even though the topic is beyond the scope of the thesis.

## 2.2 Motivation and Learning

It has long been acknowledged that motivation can be regarded as a potential drive that contributes to learning. There is a large amount of literature on motivation in which many definitions can be found. Eccles & Wigfield (2002) define the study of motivation as the study of action. Consider the following example, a student who studies hard may be described as 'highly motivated' whereas another student who is 'lowly motivated' may not study hard. Based on this illustration it seems that motivation can have an influence on one's behaviour. As stated by Weiner (1992),

> "Motivation is the study of the determinants of thought and action – it addresses why behaviour is initiated, persists, and stops, as well as what choices are made." (p. 17).

Similar to its definitions, plenty of motivational theories exist in the literature. Weiner separates these theories into two types: mechanistic theories and theories based on a cognitive approach. In mechanistic theories humans are compared to machines in which their motivation is based on needs, drives and instincts. On the contrary, in cognitive theories their motivation is based on thoughts and beliefs and thus, they have choices in regards to their behaviours. However, this is not an absolute classification as some theories share ideas from both kinds of theories such as the expectancy-value theories which is the first theory to explain motivation in the aspect of cognitive processes; nevertheless, the theories are still similar to the mechanistic theories (de Vicente, 2003). The fundamental idea behind these theories is that one will carry out activities based on his/her beliefs or reasons for doing those activities. Eccles & Wigfield (2002) also organise motivational theories that have a close link to expectancy-value models of behaviour. They group these theories into four broad categories. The first group of theories focuses on beliefs about competence and expectancy for success (self-efficacy theory and control theories). The second group of theories focuses on the reasons why individuals engage in different activities; this group consists of the following constructs: achievement values, intrinsic and extrinsic motivation, interests and goals (self-determination theory, flow theory, interest theories, goal theories). The third group of theories combines expectancy and value constructs (attribution theory, some modern expectancy-value theories, self-worth theory) whereas the fourth group of theories describes links between motivational and cognitive process (social cognitive theories of self-regulation and motivation, theories linking motivation and cognition (e.g. Borkowski & Muthukrishna, 1995; Winne & Marx, 1989; Pintrich et al., 1993), theories of motivation and volition (e.g. Corno, 1993; Kuhl, 1987)).

Learning can be regarded as the processing of information and thus, it seems to relate closely to human cognition. Several motivation theorists also try to link motivation and cognition together as they considered that there seems to be a close relationship between them. Thus, in the following sub-section we will discuss the relationship among learning, motivation and cognition.

### 2.2.1 Learning, Motivation and Cognition

There is no doubt that learning is related to human cognition since it is widely acknowledged that learning involves memory and cognitive processes. However, one may question whether motivation has any role to play between learning and cognition. It is true that motivation is regarded as one important factor that contributes to successful learning as there is plenty of research regarding this issue. Nevertheless, one may doubt whether motivation relates to cognition in some aspects based on the existing relationships between learning and cognition, and between learning and motivation. As mentioned earlier, several motivation researchers attempt to draw a link between motivation and cognition. Pintrich (1988) suggests that motivation is one mediating variable that gains little attention in most cognitive models of students' learning. In his view, it is apparent that learners who are motivated can acquire knowledge or transfer general cognitive skills across different content domains better than those who are not motivated. Pintrich et al. (1993) present an articulated discussion of links between motivation and cognition, with regards to conceptual change[1]. They discuss how traditional "cold" cognitive psychological models[2] of conceptual change do not consider the motivational and contextual factors that are likely to influence conceptual development. However, Pintrich and his colleagues state that academic learning is not cold and isolated as there is empirical evidence showing that strong motivational beliefs

[1] In general terms, conceptual change can be seen as a learning process that changes an existing belief, idea or way of thinking of a learner.

[2] The "cold" models describe the characteristics of academic learning as "cold and isolated". That is, it suggests that learners' behaviours are similar to scientists in that, when they are not satisfied with an idea, they will search for new intelligible, plausible, and fruitful constructs which will balance their general conceptual model.

such as students' self-efficacy beliefs, and their goals for learning, can influence their engagement in an academic task (see (Pintrich & Schrauben, 1992)). They describe and present preliminary evidence of how different classrooms and motivational factors such as goals, achievement values, self-efficacy beliefs and control beliefs have an influence on the change of students' mental concepts. Bickhard (2003) also argues that the concept of the separateness of cognition and motivation seems to be false. From his perspective, cognition and motivation have evolved and developed together and thus, it should be integrated more strongly. Modelling motivation and cognition as distinct processes creates difficulties in understanding the interrelationships between them including their interactions in behaviour and development.

### 2.2.2 Motivation and Self-Regulation in Learning

There is a large body of research relating to how individuals regulate their behaviour in order to achieve their learning goals (see (Boekaerts et al., 2000) and (Schunk & Zimmerman, 1994)). However, reviewing the wide range of literature on self-regulation of behaviour is beyond the scope of this thesis. Hence, we focus only on the work of Zimmerman (1989) since he attempts to draw a direct link between motivation and self-regulation. Zimmerman explains that self-regulated learners are students who are metacognitively, motivationally and behaviourally active in their own learning processes and in accomplishing their goals. That is, self-regulated learners have three major characteristics. Firstly, they use a variety of self-regulated strategies and this reflects the active learning process that involves activity and purpose. Secondly, they believe they can perform efficaciously and thirdly, they set various goals for themselves. Moreover, self-regulated learners engage in three main processes. The first process is self-observation which can be referred to the process of monitoring their own activities. The second process is self-judgement which can be regarded as the process of evaluating their performance when compared to a standard or other learners' performance. The last process is self-reactions which can be described as the process of reacting to their performance outcomes (if the reaction is favorable, especially in response to failure, students are more likely to continue their learning process). Zimmerman also acknowledges the importance of the learning context. He mentions that some environments do not allow many choices of activities or approaches which seem to obstruct self-regulated learning. Schunk and his colleagues (Schunk, 1990; Schunk & Zimmerman, 1994; Schunk & Ertmer, 2000) discuss aspects of self-efficacy and self-regulation by emphasising the mutual roles of goal setting, self-evaluation and self-efficacy. The roles of goals are discussed in two ways. Initially, goals are most effective in motivating children's behaviour and increasing their sense of self-efficacy when they are proximal, specific and challenging and that, self-efficacy may be influenced by these goals (both learning and performance goals). However, the sense of self-efficacy is likely to be higher under learning goals rather than performance goals.

Based on the relevant literature, it seems that there is a close connection between motivation and self-regulation in learning and it seems sensible to conclude that a learner who is intrinsically motivated is likely to learn for his/her own sake and to be able to develop him/herself over time and thus, a potential learning environment should be designed in such a way that aids self-regulated learning.

### 2.2.3 Key Theories of Motivation of the Research

It is no exaggeration to state that there are a large number of motivation theories to be found in the literature and, as a result, there are several attempts that try to categorise these theories as previously mentioned. These theories focus on identifying factors that are likely to influence motivation. Different theories focus on different factors. Nevertheless, these factors are, sometimes, intertwined in their nature (e.g. theories focusing on expectancies for success such as self-efficacy theory and theories focusing on the connection between motivation and cognition such as theories of self regulation).

Even though there are many motivation theories, we considered self-regulation theories to be one of the prominent theories that seem to have a major contribution to learning. This is because the theories present a way of learning that leads to positive outcomes within the constructivist framework. In educational psychology literature, researchers have linked this kind of learning to success in and beyond the school (e.g. Pintrich, 2000; Winne & Perry, 2000). As described in the earlier section, context plays an important role in this type of learning. Environments that are able to lend to self-regulation learning should allow a wide range of activity choices. Thus, it seems reasonable that in order to specify the theories of motivation in which this research will be based on, we need to specify the learning context first. As mentioned in chapter 1, the aim of the research is to create a model of motivation within a specific context and this research focuses on the context of a computer-based educational game for several reasons. First of all, this context seems to be a potential learning environment that contributes to this kind of learning (see (Rieber, 1996)). Apart from its contribution to learning, the context is likely to have a strong impact on the motivation of learners.

Since we try to model learners' motivation, the computer-based educational game context seems to be the most appropriate one.

As stated at the beginning of this section, many theories of motivation do exist in the literature; however, to my knowledge, only a small number of them have been practically applied to research in the area of artificial intelligence in education (AIED). The longstanding theory of motivation that has been widely accepted, not only by researchers in the AIED community, but also by researchers in the area of instructional design, is that of Keller (1979). Keller created a theory of motivation, performance and instructional influence and also, built a model for motivating design of instruction based on that theory (Keller, 1983) named ARCS. ARCS focuses on four characteristics that constitute motivation in learning of an individual student. These characteristics are: attention, relevance, confidence and satisfaction. de Vicente (2003) describes that,

> "Keller's (1979) theory is a macro-theory, that subsumes important concepts from the study of instruction and learning, and whose purpose is to identify major categories of variables of individual behaviour and of instructional design that are related to individual effort and performance. Thus, Keller sees behaviour as a function of the person and the environment and the theory describes the influence of these two factors on three categories of responses: effort, performance and consequences." (p. 25).

It is true that Keller's study suggests a number of influences on a student's motivation; however, the study of potential factors (or variables if one prefers) that are likely to affect motivation seems to be useful when modelling learner's motivation. Malone & Lepper (1987) propose a taxonomy of intrinsic motivation for learning which can be used as guidelines for the design of intrinsically motivating instructional environments (e.g. educational games). The taxonomy focuses on several factors that can intrinsically influence a student's motivation in learning. These factors are: challenge, sensory curiosity, cognitive curiosity, control and fantasy. However, Malone and Lepper suggest that one should consider the use of taxonomy as a way to guide and sharpen intuitions or aesthetic sensitivity rather than replacing them. 'Flow Theory' (Csikszentmihalyi, 1975) is also another theory which has been widely studied in several research disciplines including psychology, education, HCI and technology used in information systems (Pearce et al., 2005). The term 'flow' originates from a study of people participating in different activities (e.g. rock climbing and chess) and it is used to describe a state of one who is completely absorbed or engaged in an activity. As also described by Pearce et al.

(2005), Csikszentmihalyi's original model of flow is represented as a 'channel' on a plot of challenge versus skills in which the state of anxiety and boredom are separated to be on the opposite side of the channel. The model suggests that the relative balance between challenge and skill can contribute to flow. That is, an activity with low challenge can generate flow if it matches with the skills of a person (the person also has a low skill in performing the activity). In Pearce's view, Csikszentmihalyi's flow model is based on the overall-state approach which shows the importance of challenge and skill. However, he and his colleagues believe that there is no single measurement that is able to describe the emotional changes experienced by a student during a learning activity sufficiently. They raise Ainley's (2002) work as an example. In Ainley's research, students' emotions were measured two times in the learning sequence and the results showed that some emotions frequently changed noticeably between those times. Based on their belief, they rather focus on how flow may change during a learning situation (they term this as the process of flow) and what factors are likely to be related to those changes.

We considered that Keller's ARCS model and Malone and Lepper's taxonomy are suitable to apply to our research for several reasons. First of all, both of their studies were done on a computer-based instruction basis and that they are suitable to the context of our research (computer-based educational games), especially that of Malone and Lepper. Furthermore, there is research which attempts to categorise the variables extracted from the ARCS and Malone and Lepper's taxonomy which is that of de Vicente (2003). He developed a general model of students' motivation based on these variables which we considered to be useful within our study (more details on his research will be described in the next section). Even though there seems to be a solid reason for why we base our research on the above theories, one may question further why not flow theory? It is true that several researchers have based their studies on the theory of flow, especially, research done within the online learning context (e.g. web use and navigation, web marketing, etc. (Pearce et al., 2005)). We considered that flow theory is not the most appropriate theory to be applied to our research for several reasons. At the outset, the theory focuses only on two variables (challenge and skill); however, our context seems to involve more variables and we considered that it would be useful to take into account these variables as they could constitute a fruitful model. In addition, the theory focuses on the *state* of flow (the point where a person is in the flow channel) and seems to pay less attention to the *process* of flow (the change of flow during a learning period). As described in chapter 1, the focal point of our research is to make progress in determining the change of students' motivation when learning takes place within the educational game context. In other words, we rather focus on the changing process of motivation with regards to the factors (or variables) that cause the change. Thus, it was considered that the theory of flow might not be suitable compared to those of Keller, and Malone and Lepper.

## 2.3 Motivation and Learning Environments

The potential characteristics of computers have long been recognised, and the assimilation of computers into education, as a role of tutor, has changed the learning and teaching process. Lepper & Chabay (1988) describe the evolution of computer-based tutors that initially were very simple, basing their responses to students on straightforward algorithms. After that, computer-assisted instruction (CAI) started to gain a reputation since its development began to draw on psychological research concerning the processes of learning. Due to newer principles and techniques developed after the CAI era, intelligent tutoring systems (ITSs) or intelligent computer-assisted instruction (ICAI) systems have been widely constructed in order to aid learning. ITS and ICAI are described as having three main components: an expert, a diagnostician (or student model builder), and a tutor. The function of the expert component is to solve the kind of problems presented to a student. The function of the diagnostician is to diagnose the student's bugs or misconceptions and to map discrepancies between the student's knowledge and strategies, and those of an expert. Finally, the function of the tutor component is to determine what guidance or feedback should be provided based on the student model built by the diagnostician part. There are a number of early famous examples of programs that are expert problem solvers and sophisticated diagnosticians (e.g. Burton, 1982; Brown & Burton, 1978; Sleeman, 1982; Brown, Burton & de Kleer, 1982; Clancey, 1982, cited in (Lepper and Chabay, 1988)). There are also several competent tutoring systems developed recently in order to get students to acquire what is called task domain[3] (e.g. Algebra Cognitive Tutor, Andes, AutoTutor, Sherlock, SQL-Tutor and Steve). Lepper and Chabay point out that despite these intelligent characteristics, this kind of computer-based tutor still lacks the capability to decide how to interact with a student in a more human-like manner since the information provided for these intelligent tutors focus on cognitive rather than social aspect (e.g. affect and motivation) of the tutoring process. They argue that,

[3] The term 'task domain' is defined as the information and skills being taught by the tutor (Vanlehn, 2006).

> "…cognitive principles alone do not provide an adequate basis for determining what a tutor should do, or how, or when. We assert that motivational components of tutoring strategies are as important as cognitive components, and more generally, that truly personalised along motivational as well as cognitive dimensions (Lepper & Malone, 1987). Hence, we suggest that important benefits may arise from a serious consideration of techniques for creating computer tutors that display "empathy", as well as intelligence, in their interactions with students." (p. 243 – 244).

Lepper and Chabay also raise some important questions regarding motivational principles and strategies that can and should be incorporated into computer tutors and how this incorporation may affect students' learning and performance. In response to his question, Lepper et al. (1993) outline some of the strategies that expert human tutors appear to employ in order to achieve major motivational or affective goals (confidence, challenge, control and curiosity) which have been identified as important to the development of an intrinsic motivation to learn (Lepper & Malone, 1987; Malone & Lepper, 1987). Self (1990) mentions the characteristics of a student model module in an ITS that as each student has different prior knowledge and learning experience, the module needs to include this information in the model in order to individualise an instruction in a way appropriate to his/her existing knowledge. However, students not only have different background knowledge, but they also have different learning preferences, styles and strategies; furthermore, they may have particular interests or a special social background. Thus, the ideal student model should take these aspects into account so that, an ITS may present materials that are likely to suit their learning characteristics. Self's view implicitly suggests that research in ITS, particularly student modeling, requires further exploration into the social aspects of learners (e.g. affect and motivation). Self also proposes some guidelines which may help in constructing effective student models. These guidelines are described under four 'slogans'; some of which are used by motivation researchers in the ITS community (e.g. de Vicente, 2003).

Recently, there has been increased interest among researchers in the AIED community in creating an 'empathetic' computer tutor. A large amount of research has been conducted in order to build a tutoring system that has emotion (known as affective computing which will be discussed in section 2.4). Similarly, there has been an increase in research that attempts to create a tutoring system that takes into account the motivational aspect of learners or incorporates human motivation into tutoring systems.

There is a large amount of research that takes into account the aspect of motivation into the design and development of tutoring systems/learning environments. These systems/environments range from ones aiming at motivating students to learn from instructional materials (static systems[4]) to ones that are capable of adapting themselves in order to motivate the learners (dynamic systems[5]). However, we focus on research that appears to be one-to-one interaction between a student and an educational system rather than those that work with groups of students (e.g. Chen et al., 2005) since the latter kind is not in the scope of the thesis. There are many static and dynamic systems existing in the literature. To review all of them is not the focus of this research and thus, some of the relating systems are chosen as examples. The examples of motivating static systems are: Ghostwriter (Robertson & Good, 2003), MOSS (Waraich, 2002) and BAT (Waraich, 2004) Ghostwriter is a virtual learning environment designed as a tool for educational drama. MOSS and BAT are game-like learning environments developed to teach map reading, and binary arithmetic and logic gates accordingly (more details about these systems will be explained in chapter 3). As for the examples of motivating dynamic systems, Georgouli (2002) presents the design of an intelligent assessment system[6] that is able to adapt itself according to a student's aptitudes and motivational state in order to motivate him/her (e.g. offering appropriate help).

Even though there is an increasing amount of research dealing with motivational issues, only a small number of studies deal explicitly with motivation in ITS. One foundational piece of research that has been widely acknowledged is that of del Soldato & du Boulay (1995). They created an intelligent tutoring system named MORE which included a motivational module that could perform motivational state modeling and motivational planning. The system aims at teaching Prolog debugging on a one-to-one basis and consists of three components: the domain-based planner, the motivational planner and the negotiation planner. The function of the domain-based planner is to offer a series of increasingly difficult Prolog debugging problems to a student. The system can move the student faster or slower through the curriculum depending on the student's performance. The function of the motivational planner is to get a variety of inputs from the student (e.g. comments about willingness to tackle difficult problems, difficulty of

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[4] The systems that are created using techniques/contexts that are likely to be motivating to learners (e.g. virtual learning environments, game-based learning environments, etc.).

[5] The systems that try to detect motivational states of learners at runtime and adjust the nature of the interactions according to the values of these states.

[6] An assessment system is an educational system that is able to identify the gaps in a student's knowledge of the subject domain and to check the reasons for that as quickly and as accurately as possible.

work chosen, use of available help), to build a motivational model of the student based on three variables: effort, confidence and independence and to tailor the system's reactions based on the model. However, there were, sometimes, conflicts between suggestions made by the domain-based planner and those made by the motivational planner. As a result, the negotiation planner was also implemented in order to decide whether the system should traverse the domain or increase the student's motivation. Matsubara & Nagamachi (1996) constructed a motivation system which aims at motivating a student to learn by giving appropriate encouragement, praise or reproach messages. They proposed the human model containing several elements of psychological characteristics; these characteristics were measured using a questionnaire method. They also prepared fuzzy if-then rules in order to give efficient motivating messages to the student according to his/her model. However, their system is based on the idea that extrinsic motivation is a better approach to motivate the student than intrinsic motivation in which they claim to be dependent upon the domain knowledge. de Vicente & Pain (2002; de Vicente, 2003) conducted research that also dealt explicitly with motivation in ITS. They detail an interesting approach to the detection of motivation. Firstly, they performed a study with students in order to see their reactions to and the usefulness of self-report approach to motivation diagnosis and for this study, the prototype ITS, MOODS, was created as a simple tutoring system with an added motivation self-report facility. The facility was based on a motivational model which they developed based on the relevant literature and with this facility students could report on their motivational state during interaction with MOODS. The results from the study show that the method of self-report can be used satisfactorily for motivation diagnosis in ITSs. Later, they performed another study (motivation diagnosis study) to extract and formalise tutor's knowledge in relation to motivation detection. In this study the participants were asked to watch the recorded interactions of a student with MOODS and infer or comment on the motivational state of the student. Also, for this study, A_MOODS was built with the ability to replay the actions of student interaction with MOODS. Based on the data obtained from the participants in this study, a set of 85 motivational rules were developed. Another study was performed in order to evaluate these rules. In the study the participants were presented with an instructional interaction context and were asked to rate the rules that could be applied under those conditions. Based on the results from the study, the original set of rules was reduced from 85 to 41.

M-Ecolab (Rebolledo-Mendez et al., 2005; 2006) is a system that was created aiming to deal with the motivational aspect of learners. M-Ecolab is an extension of a system, Ecolab, designed to teach the concepts of food webs and chains to 10-11 years old (Luckin, 1998; Luckin & du Boulay, 1999). The Ecolab system presents an on screen laboratory which introduces various creatures and populations of creatures to see what eats what and how the population size varies over time. M-Ecolab was developed to provide motivational scaffolding through the use of on-screen characters. The system models learners' motivational states (effort, independence and confidence) at interaction time and reacts to that by offering a motivating activity as well as by encasing the interactions with the system in the aspect of an overall narrative involving two on-screen characters. The system was evaluated to test the effects of motivational scaffolding and the results suggested a positive effect of the motivational scaffolding, especially for students who were primarily de-motivated. These students changed their behaviours in a way that demonstrated higher learning gains; they became challenge seekers and inclined to exert more effort. However, the researchers state that they acknowledge the fact that the results have been derived from a small sample and that their motivational modelling needs further development. However, their intention is to present motivating strategies to de-motivated students only, not to all students.

According to the literature, it is true that a few learner models have been developed in the context of ILEs recently such as the motivation model developed by de Vicente (2003) and the situation model developed by Porayska-Pomsta (2003). The motivation model of de Vicente is useful in that it provides various motivational variables extracted from the literature in motivationally instructional design and these variables are broadly categorised which gives us a better insight into the structure of a learner's motivation. However, his model seems to be generic and it can be applied to every domain and every student. The situation model of Porayska-Pomsta is useful in that the factors that appear in the model are based on both literature and evidence from the analysis of two sets of real educational dialogues. These factors are: student's confidence, student's interest, time left, amount of material left, difficulty of the topic, importance of the topic, correctness of student's previous answer and student's aptitude. However, not all of these situational factors are related to motivation; only two of them seem to be relevant: confidence and interest. We believe that in our research context there are other variables that are as important as these two variables (e.g. control, challenge, etc.).

Our research is closely related to the work of de Vicente (2003) as our aim is to create a model of learner's motivation within a specific context (the educational game context) and thus, we decided to employ his motivation model and made some adjustments to it (by adding and dropping some variables); this will be discussed further in chapter 4. The model focuses on the interaction between and among motivational characteristics of learners and features of an educational game ILE. Also, the model can be applied to not only the intelligent application, but also the interactive application.

## 2.4 Affective Computing

Parkinson and Colman (1995) attempt to classify human mental functions by defining three separate, but intertwined areas: cognition (thinking), affect (feeling) and conation (willing). They state that,

> “Emotion is one of the most important and thoroughly explored forms of affect, and motivation is essentially just a new name for conation, therefore, this volume might be seen, from one angle at least, as spanning almost two thirds of psychology. According to a simpler classification, the two basic operations of the mind relate to knowledge and desire, and emotion and motivation both belong mainly in the latter category.” (p. xi).

Parkinson and Colman also state further that,

> “Emotion and motivation both depend on the relationship between the organism and its environment. In the case of emotion, the emphasis is on the evaluative aspect of this relationship: how the situation makes the person feel; in the case of motivation, it is how individual acts with respect to the situation that is of interest (Kuhl, 1986). There are obvious links between emotion and motivation, because situational evaluations largely determine action priorities: liking implies affinity or attraction and disliking repulsion” (p. xi-xii).

According to their statement, a connection between both emotion and motivation seems to exist. de Vicente (2003) suggests that emotions are often precursors of motivational phenomena; they refer to different concepts, but both of them influence human behaviours towards environments. Since there seems to be a close relationship between emotion and motivation, it is sensible to provide a brief overview of research that attempts to integrate human emotion into computing. However, to review work in this area is outside the scope of the thesis.

Research that brings about both emotion and computing disciplines is termed as “Affective Computing” in which it is defined by Picard (1997) as, “computing that relates to, arises from, or deliberately influences emotions.” (p. 3). Picard also suggests applications of affective computing in various areas (e.g. entertainment, learning, social development, etc.). She also mentions that several applications can be engineered with present technology such as affect in synthetic speech, simple synthetic emotions and emotional expressions in animated agents; also, there are more sophisticated applications which involve recognition of user affect, reasoning with emotional cues and understanding how to intelligently respond given the user's situation.

One significant characteristic of affective computers is that they are able to recognise emotions (or detect emotion); however, according to Picard, the ability in detecting precise human emotions by computers seems to be difficult to achieve. Nevertheless, there are many available cues for emotion detection ranging from verbal (speech) to nonverbal ones (e.g. eyes, hands, posture, body rhythms, smell, touch, etc.). Research in the area of emotion detection can be categorised into different groups based on sources of emotional messages (e.g. research recognising emotions through facial expressions, research recognising emotions in speech, research recognising emotions using physiological data, etc.). Conati & Zhou (2002) carried out an interesting study which might be categorised as work that relates to emotion detection since their attempt focused on detecting students' emotion within the context of an educational game. They devised a probabilistic model that relied on Dynamic Decision Network (DDN) to assess students' emotions during the interaction with an educational game. The model was created by combining the OCC cognitive theory (Ortony et al., 1988) of emotions with data gathered during two user studies. The model was used by the pedagogical agent in order to generate interventions for students that could enhance their learning.

Another important characteristic of affective machines is that they can show a degree of emotion in order to create a better interaction between man and machine. This characteristic can be regarded as simulation of emotions (emotion synthesis). Similar to research in emotion detection, several research has been done in the area of emotion synthesis. de Vicente (2003) raise the creation of virtual-pets – Tamagochi as a successful example of research in this area; however, he suggests that interesting research in this area is research based on studies of human emotions that utilises emotion models in order to help the computer to better synthesise emotions (e.g. the work by Colby (1981) and the work by Elliott (1992), cited in (de Vicente, 2003)) which focus on understanding human emotions and providing models for emotion synthesis).

## 2.5 Summary

As can be seen from the review presented in this chapter, there is a growing research interest in the issue of motivation in the AIED community. Several attempts have been made to incorporate motivation into both intelligent and interactive learning environments and there are indeed works that try to create the intelligent systems (or learning environments) which can model learners' motivation and adapt learning materials according to the model (e.g. MORE, M-Ecolab) used. However, these systems focus on modeling a small set of motivational variables (effort, independence and confidence) at interaction time and reacting to that based on ad hoc strategies. We considered that there seem to be other important variables in the context of an educational game that are likely to play an important role on learners' motivation (e.g. curiosity, fantasy, etc.) and it is worth conducting further investigation on this issue. Also, the models created by those systems focus on input and output and thus, it is difficult to see what is going on when a learner is motivated or de-motivated. This research, on the contrary, attempts to create a model of learners' motivation that shows the process of how one is motivated to learn or not motivated to learn through a game instruction.

We chose to build a motivation model within the context of an educational game as it was considered to be the medium that can powerfully drive the motivation of a learner. We will discuss issues relating to computer games in chapter 3.

# Chapter 3

# Computer Games, Narrative and Motivation

## 3.1 Introduction

Computer games have been widely acknowledged as being able to engage their players for several hours. Several features of the games that increase the motivation of players have been identified by a number of analyses and among these are narrative and a fantasy context (e.g. Malone & Lepper, 1987; Prensky, 2001). Due to this powerful nature of computer games, recent research has tended to focus on the issues of how to incorporate computer games into learning and how to exploit their potential power to promote deep engagement when learning. Inevitably, some concerns relating to the negative impact of the games (e.g. aggressive behaviour) do exist among parents, educators, and even researchers (Bensley, 2000; Anderson & Dill, 2000). The debate on whether computer games really support or undermine learning has become an issue.

In this chapter we introduce the term 'microworlds' which is commonly used in computer-based learning environments and we illustrate the use of computer games in an educational context, specifically their contribution to learning and motivation. We also discuss the narrative feature which is gaining increasing interests from people in both education and the computer games industry. The feature is discussed with regard to its contribution to learning. Then, we move on to discuss the issues of bringing computer games into learning context, with particular emphasis on their advantages and disadvantages towards learning.

## 3.2 Introduction to Microworlds

As mentioned by Waraich (2002), 'microworlds' are widely used in computer-based learning environments (for instance Rieber, 1992; Papert, 1981; Quinn, 1994; Malone, 1981). Rieber (1996) defines microworlds as a small, but complete, version of some domain of interest. The idea of microworlds in those learning environments is that they are artificially constructed based on the principles of constructivism. Constructivism is supported by the theory that learners/students gain an understanding through interactions with the learning environment and they construct their own conceptualisations and solutions to problems. Rieber (1996) also states that microworlds have two main characteristics. Firstly, a microworld presents a learner with the simplest case of the domain even though he/she will typically be given the ways to reshape the microworld to further explore more complex ideas. Secondly, a microworld must be matched to the cognitive and affective state of the learner. This means learners quickly know what to do with the microworld with little or no training on how to use it. These two major characteristics provide a large set of complex assumptions and expectations for a microworld designer to meet and in Rieber's view, the most important aspect is that learners are expected to self-regulate their own learning in a microworld. According to Zimmerman (1989; 1990), self-regulated learning has three main characteristics. Firstly, learners discover that the environment is intrinsically motivating. This means they find their participation in the activity to be its own reward which does not involve external incentives (Lepper & Malone, 1987; Malone & Lepper, 1987). Secondly, self-regulated learners actively engage in planning and goal-setting and they are able to monitor and evaluate their own learning. Thirdly, self-regulated learners are behaviorally active. They tend to choose and structure the environment to suit their learning styles. Based on Rieber's view about the most important aspect of microworlds and the characteristics of self-regulated learning, it seems that there is a connection between microworlds and the concept of intrinsic motivation.

The characteristics which are general to all intrinsically motivating learning environments are specified by motivational researchers and these characteristics are: challenge, curiosity, fantasy and control (Lepper & Malone, 1987; Malone, 1981; Malone & Lepper, 1987). Computer games are likely to be the specific type of computer-based instruction that closely match with these characteristics. Csikszentmihalyi (1990) developed the flow theory of optimal experience which relates to self-regulated learning that focuses exclusively on adults. This theory provides an important framework for an adult's motivation in learning. Csikszentmihalyi (1990) defines 'flow' as

> "…the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it." (p.4).

Some early analyses describe an experience with computer games as it contributes to ‘flow’ which is likely to be useful if it can be incorporated into the environments designed to support learning (Malone, 1980; Prensky, 2001).

## 3.3 Narrative and Learning

It has long been recognised that narrative or storytelling relates to the teaching and learning process. Abrahamson (1998) sees narrative as the foundation of teaching. Berg (2000), referring to Abrahamson (1998), calls learning the understanding of new events in the context of past events. According to Bruner (1996), human development is based on the use of narrative in order to make sense of everyday experiences. He also emphasises the pursuit of an individual’s meaning and knowledge, with his/her socio-cultural experiences acting as an influential power. Thus, based on Bruner’s view narrative can be referred as a major mechanism in learning. In the modern classroom, narratives are used to teach in an entertaining fashion. Narratives in the classroom are used with students in the younger age groups; however, with mature students, narratives lose their importance in the curriculum. Nevertheless, Laurillard (1993) implicitly suggests the design of teaching material for higher education within a narrative framework. She states in her book that the material has to address both the direct experience of the world, and the reflection on that experience which will produce the intended way of representing it (Laurillard, 1993, p. 29). Plowman (1996) and her research shows a re-surfacing of narrative in a new context, and a new format. She studies narrative in the context of multimedia and the characteristics of technological media have resulted in changes in the way in which narratives are formed, shared and stored.

### 3.3.1 Narrative and Cognition

It is known that narrative or storytelling shapes our knowledge and everyday experience and that human have a predisposition to find and create narrative which determines ways in which we acquire language (Plowman, 1998). Thus, it seems that the role of narrative is central to our cognition from earliest childhood.

Traditionally, narratives are considered to relate to working memory. There is a major research (Bower & Morrow, 1990; Thorndyke, 1977, cited in (Plowman, 1996)), which focuses on written texts, that suggests that texts which are structured differently from a learner’s mental model of narrative can create excessive demands on the learner’s cognitive process. However, memory can be used more productively when the text is well structured and navigable. Research by Plowman (1998) reveals that hypermedia structures, sometimes, can lead to children losing track, not only of the structure, but also of their thinking. However, there are several aspects of interactive learning environments (ILEs) which can assist learning. As stated by Plowman (1998) that, 'Being able to control pace and sequence can be reassuring, the ability to follow up paths of interest and gather more information can be motivating, different representations of information can be helpful, and having to think about which routes to take can make the learning process more explicit.'.

There is an old saying that 'there are two sides to every story' which seems to be true for the aspects of ILEs. Again, as stated by Plowman (1998) that, 'some of these same features, along with other defining characteristics of interactive media, can also act as impediments to learning'. These include the demands of interactivity (no progression without interaction), the simultaneous use of multiple media, interpretations of icons and other screen conventions, making connection between task activities, demands on memory, and problems navigating and visualising the journey through the materials.'. Plowman (1996) conducted a study involving children using four different interactive multimedia programs and the results of the study suggest that in such programs children need the structure offered by narrative to aid their understanding and navigation. Plowman points out that one of the key features of interactive multimedia programs is the concept of control which means a learner can choose which routes in the programs that he/she prefers to take. This can be regarded as the powerful characteristic of such programs but it can also be considered as the cause of confusion at the same time. According to Plowman's view, it seems better to acknowledge a variety of narratives as a source of richness and ensure their coherency rather than to remove this potential feature. Furthermore, she suggests that some of the negative effects caused by the fractured narrative of interactive media can be diminished by following some guidelines when designing such media (see (Plowman, 1996) for more details) and the important issue is that instructional designers need to consider a way to develop a narrative which is dynamic and motivating by integrating the rhetoric with powerful imaginary elements.

Recent research, particularly in the AIED community, shows increased interest in bringing narrative and technology together to assist learning. Several forms of learning environments (e.g. virtual learning environments and educational games) have been built by narrative researchers (e.g. Robertson & Good, 2003; Waraich, 2002) in order to develop some important skills (e.g. problem-solving skill and storytelling skill) and cognitive skill. Apart from aiming to develop these major skills, those systems were developed with regards to the issue of motivating learners to learn, especially those of Waraich (2002). Based on this literature, it was considered that narrative relates to, not only the aspect of cognition, but also the aspect of motivation.

### 3.3.2 Narrative and Motivation

A number of researchers have investigated the relationship between motivation of students and their ability to learn from computer-based instructions (Lepper et al., 1993; Lepper & Malone, 1987; Malone & Lepper, 1987). The results of these studies show that the students can benefit from learning when the learning activities take place in a motivationally embellished setting. In other words the students tend to feel motivated to learn when the materials are embedded in the fantasy context such as simple educational games that use a basic narrative. Furthermore, the studies suggest that some characteristics in a fantasy-like learning environment are likely to offer a high degree of motivation such as an increase in a learner's sense of cognitive surprise and curiosity, the will to conquer in a challenging situation and the learner's feeling of being in control.

Quinn (1996) also points out that computer games seem to be an effective learning environment and he suggests that the games that have a tight coupling between narrative and learning goals are likely to offer an engaging environment to learners. However, the environment should provide pedagogical support for the learners in order for them to be able to reflect on the activity.

Waraich (2002) believes that a game-based learning environment strongly coupled with a narrative can engage learners to learn with the environment. Based on his belief, he developed two game-based ILEs as prototypes: MOSS aiming to teach map reading, and BAT aiming to teach binary arithmetic and logic gates. The design of the prototype ILEs was based on the learner-centred Informant Design (ID) methodology. The methodology is based on a close co-operation between instructional designers and 'informants' in order to create a system that meets the needs of the learners. The term 'informants' in his study refers to learners/students (children) who can contribute to the design of a narrative (in the aspect of evaluating what is good or bad) for an ILE, but they cannot relate this to the learning objectives. To evaluate the prototypes in the aspect of both learning and engagement of the students, he adopted qualitative and quantitative strategies. Students' learning was assessed using pre- and post-testing whereas their engagement was assessed using four methods: direct observation, questionnaire, interviewing and informal comments from both the students and tutors. The results of the evaluation suggest that the use of a strong narrative in MOSS can have a strong impact on the students' motivation. As for BAT, the results suggest that the use of a game-like learning environment that incorporates simple narrative and goal-directed activities can motivate students to gain abstract knowledge.

Robertson & Good (2003) describe Ghostwriter as an educational virtual environment designed as a tool for educational drama. The design of Ghostwriter aims at developing writing skills as well as promoting personal, social and moral development. Ghostwriter was developed using commercial games technology (Unreal) and thus, it contains high quality graphics and audio. Ghostwriter was used in a field study in order to evaluate the degree to which pupils experienced social presence during the Ghostwriter session. The results of the evaluation suggest that Ghostwriter can illustrate the benefits of using commercial computer games technology to create educational virtual environments which are tailored to a curriculum. Also, Ghostwriter can be regarded as an engaging learning environment compared to the games which children play in their free time. Thus, the environment also seems to have a strong motivational impact on the pupils even though it was designed to develop major skills in an educational curriculum.

Rowe et al. (2007) explored the relationship between narrative-centred learning and student motivation. They draw connections between motivational factors (challenge, curiosity, control and fantasy) and narrative context through an examination of their narrative-centred learning environment, CRYSTAL ISLAND. The results of their focus group studies with middle school students suggest that the narrative elements of plot, characters and setting can contribute to motivation in learning of students through their experiences with the narrative-centred learning environment.

Based on the literature described so far, the consideration towards narrative in having a potential contribution on learners' motivation seems to be reasonably confirmed.

## 3.4 Computer Games and Learning

### 3.4.1 Bringing Computer Games to Learning

It is not an exaggeration to state that nowadays, computer games are an increasingly an important part of our culture as a whole as can be seen from the global market which is worth billions of dollars and add on activities ranging from published magazines to internet communities. Young people are likely to rely more on computer games as a part of their leisure lives than ever before. They seem to spend a long time in playing games with their friends or on their own. An interesting question is what makes computer games successful at attracting young people? Malone (1981) discusses four factors which can be found in successful computer games: goal, uncertain outcome, fantasy, cognitive curiosity. A game should contain activities which have clearly articulated goals. Also, it should provide variable levels of difficulty and should not be completely predictable. Furthermore, the game should be emotionally appealing and any skills, embedded in the environment, should be related to the game. In addition, any audio and visual graphics, used for decorating the system, should enhance the fantasy. Prensky (2001) analysed computer games to find out their engaging aspects, why they are so captivating in particular. Most of his findings correspond with those of Malone. Prensky suggests that the ‘fun’ aspect in the games is the great motivator. He also mentions that computer games are becoming much more detailed in their representation and thus, the narrative or story is becoming a bigger part of games. He considers narrative as a powerful element that is capable of motivating players since narrative gives players strong emotions.

Because of the popularity of computer games, researchers, teachers and designers of learning resources are starting to ask how this powerful new medium can be exploited in order to support learning. According to the literature (Rieber, 1996; Amory et al., 1999), there seems to be a close relationship between play and learning and there are some characteristics of computer games that are likely to contribute to learning. Computer games are a medium that can improve learning through visualisation, experimentation and creativity of play (Betz, 1995, cited in (Amory et al., 1999)). Also, computer games often include problems that can increase critical thinking (defined by Huntington (1984), cited in (Amory et al., 1999)) and problem solving skills. According to Kirriemuir & Mcfarlane (2004), children’s learning competencies can be improved through the use of computer games. For example, the use of and the familiarity with computer games may play an important role in developing the children’s skills in the effective use of computer-mediated information resources. The confidence of children may also be improved when they use computers for more professional applications (Mackereth, 1998, cited in (Kirriemuir & McFarlane, 2004)). Furthermore, computer games are likely to offer children social, communication and peer based activities which seem to contribute to learning. Children may learn how to collaborate with others through processes of discussion and reflection on games embedded in peer group cultures (Williamson & Facer, 2003, cited in (Kirriemuir & McFarlane, 2004)). In addition, Prensky (2001) argues that young people nowadays expect to learn with different approaches and he summarises the ‘new vs old’ characteristics of methods of learning. Based on Prensky’s argument, Kirriemuir & Mcfarlane (2004, p. 17) offer some explanations about how computer games can make a change in ways of learning. For instance, computer games encourage young people to develop the ability to process information very quickly, and to process information in parallel from a range of different sources. The skills of learners in exploring information (in a non-linear fashion) and in creating links are likely to develop. Furthermore, computer games seem to make a change in the model of learning of learners; that is, the learners appear to have the model of doing in order to learn, rather than learning in order to do.

Apart from the benefits to learning, computer games also contribute to motivation in learning which seems to gain lots of interests in recent research since motivation has long been considered to contribute to learning (see chapter 2). Lepper & Cordova (1992) empirically investigated whether students can cognitively and motivationally benefit from appropriately designed motivational embellishments of educational activities. The results from their studies suggest that significant educational benefits can be gained from effective attempts to increase children’s intrinsic interest in the activities that appear in the presented instructions. They also point out some limitations of using the motivational embellishments in the learning activities. They refer to Lepper & Malone’s (1987) work that increased motivational appeal will lead to increased learning if the actions required for students to learn the material presented in an activity and the actions required for students to enjoy the activity are matched. If this match does not occur, there seems to be negative effects on learning. In other words, the additions of the motivational embellishments (e.g. illustrations, exciting anecdotes) may enhance learning if they draw the attention of students to important themes and arguments in an informational passage; on the contrary, if the attention of learners is drawn toward irrelevant aspects of the passage, they may have harmful effects on learning instead. Thus, they made a further suggestion that the use of motivational embellishments have to be planned carefully, to ensure that they support, rather than undermine, learning. Lepper & Cordova’s (1992) findings are supported by Thomas & Macredie (1994) as they report that learners are intrinsically motivated to educational games that contain appropriate design and are systematically structured. Rieber et al. (1998) believe that play is an important part of learning. A serious play, as they define it, is play that focuses within a learning environment, can help learners construct and reflect their understanding. In their view computer games are likely to offer a new way for learning and they also contribute to intrinsic motivation which is the long-standing goal in education.

Despite the contribution to learning and motivation, some aspects of computer games are criticised by researchers and educators. Some questions have been raised which create a long-standing debate over the use of computer games to educate learners (e.g. should learning be fun? are there any risks in bringing games into education? are students really motivated to learn from the games, or they are motivated to other aspects of the game?). There is no doubt that computer technology can potentially improve the way people learn; however, there seems to be a negative side of relying too much on the technology without careful considerations as stated by Okan (2003), "…one unforeseen danger of adapting computer technology into education so enthusiastically is that learning is seen as fun and entertainment. Learners who are exposed heavily to the internet, video games and ready-made images presented by multimedia develop a new attitude towards learning. As Bloom & Hanych (2002) observe, equating learning with fun suggests that if students are not enjoying themselves, they are not learning. In other words, learning becomes an obstacle that learners need to overcome…". This view is supported by Postman (1985) and Setzer & Monke (2001) (both are cited in (Okan, 2003)). Nevertheless, in Okan's (2003) view, fun is not necessarily an opposite of serious activities such as learning as long as there is a negotiated balance. In other words, fun can appear in serious activities and similarly, learners can also find seriousness in the fun activities. Furthermore, there has been an argument for the use of edutainment software such as educational games whether they are motivating to students in the aspect of learning or playing. Referring to Okan's (2003) view, in order for educators and researchers to recognise the real potential of such software, there is a need to look beyond issues that engage learners at a superficial level (e.g. packaging, graphics and special effects); rather, the focus should be on issues that impact on a cognitive level of learners such as tasks or activities. Tasks or activities must be designed in such a way that learners' interests can be raised and have to be balanced with those entertainment features to develop intellectual ability. According to Kirriemuir & Mcfarlane (2004), there are several concerns around computer games that may affect learning if they are brought to the curriculum. Firstly, computer games may displace other traditional activities such as social play and physical recreation. Children may spend a long time playing games and may become addicted to them which in turn may lead to the exclusion of all other activities that develop seemingly necessary skills for learning such as communication with others. However, this issue is likely to be resolved to some extent as can be seen from the use of on-line games which encourage collaborations and co-operations among children. Furthermore, the issue of violence within computer games seems to be a major concern for all related parties (parents, educators and researchers) and it stimulates a major debate amongst academic researchers. However, based on Kirriemuir & Mcfarlane's (2004) reviews of research, it seems that the issue of games and violence will not be resolved simply since there is a large amount of research conducted around this issue, but this research has failed to reach a consensus. According to their view, this may be because the research may need to involve a considerable number of players and it may take a long period of time (years instead of days or hours) to examine the change in aggressive behaviours caused by the games or other related factors.

We view computer games as tools that can aid or enhance learning and the use of computer games may well be grounded in constructivist theory. In other words, the games should act as the cognitive tools to engage students in learning rather than to play with computers. If we are successful at creating a computer game that contains such characteristics, there seems to be benefits to learning since students can learn in a fun context which is congruent with the curriculum. Also, gains in learning seem to be increased because students are intrinsically motivated to learn for their own sake and this leads to self-regulated in learning. According to Rieber et al. (1998), there are research and theories that describe the merge between motivation and self-regulated learning (Butler & Winne, 1995; Schunk & Zimmerman, 1994; Zimmerman, 1989; Zimmerman, 1990, cited in (Rieber et al., 1998)). Learners, who engaged in self-regulation learning, usually hold three characteristics. Firstly, they find the learning objectives interesting for their own sake and do not require external incentives to participate. Secondly, they are able to monitor their own learning and are able to identify their troubles. Finally, they can take essential steps to modify their learning environment to facilitate learning. The most successful students seem to self-regulate their own learning.

### 3.4.2 Computer Games and Narrative

As mentioned earlier, Prensky (2001) considers narrative as a powerful feature in computer games that is able to motivate players and he raises an important issue that both the narrative people and the game people have been faced with the question of how to combine narrative with games consistently, especially in the education context. Murray (1997) indicates that the plots of computer games are drawn on the fable themes which are frequently used in fairy tales. Murray hypothesises that Propp's (1968) model offers a systematic approach to an analysis of narrative and the model seems to be able to apply with the computer-based systems appropriately. Murray's hypothesis is supported by Poole (2000) who suggests that plot actions are the focus of computer games in general. Propp's model has been used as the theoretical basis for story generation systems (e.g. Prada et al., 2000). Propp attempts to explain why stories from around the world are naturally similar. In order to explain this, he analysed one hundred Russian folktales to establish standard elements for the classification of these tales. The conclusion of his analysis is that basic important components of narrative do exist in these folktales and 31 functions were extracted as general principles of the narrative. Waraich (2002) states that,

> "the significant aspect of Propp's work (other than the attempt to develop a canonical form for narrative) is that the functions he describes are important for the development of the overall plot. It is also noteworthy that the mythic nature of the functions Propp has identified is similar to the narrative structures often used in computer games (Murray, (1997) and Poole, (2000))." (p. 23).

Waraich (2002) explains that there are three general mechanisms used for the creation of interactive story. The first type is the structure in which the narrative contains several paths; however, the difficulty for applying this kind of narrative structure is that all possible paths must be carefully constructed (branching structures). The second type is the structure in which the narrative path is predetermined or fixed and interactivity is provided, but with limited effects on the plot (linear narratives). The last type is the structure in which the player's actions have an important impact on the narrative and thus, the narrative is emergent rather than pre-designed. Waraich also suggests that computer games which rely on plot-based narratives seem to benefit from applying Propp's model with the branching or linear structure; this approach has been used in computer games for some time. Dunniway (2000) suggests that there are some genres of computer game which require a strong sense of narrative compared to other genres; these genres are adventure, role-playing and strategy games.

A linear narrative with a branching structure is commonly used when designing computer games. In this kind of narrative the plot is built along syntagmatic scenes[1]; branches can occur from this fundamental structure, but they will always lead back into the plot. Computer game genre that frequently uses this kind of narrative is adventure-based games. According to Sherwood (1991), adventure games have been widely used in an educational context compared to other types of computer game. The reason behind

[1] The term 'syntagmatic scenes' is the term used in film and television and can be referred to the scenes that are sequentially related to others.

the popularity of the adventure game genre in educational settings is because normally, adventure games can develop skills such as controlling a story, solving problems and puzzles. As suggested by Sherwood (1991), students tend to enjoy problems that require intellectual ability in solving the problems and they also seem to like the problems that are naturally contextualized. Thus, the students' motivation can be increased by a well-designed adventure game and this seems to increase the students' persistence in solving the problems. Furthermore, the study by Amory et al. (1999) in an attempt to identify the most suitable game type to their teaching environment confirms that adventure games appear to provide the best foundation for the development of teaching resources. Also, their findings are supported by the work of several authors such as Quinn (1994; 1996).

However, there is another type of narrative which has attracted researchers' attention recently, an emergent narrative. Emergent narrative uses a character-based approach rather than a plot-driven approach. The systems that use this kind of narrative require users to actively participate in the construction of narrative in a highly flexible real-time environment. The development of the story depends on the interactions between a user and intelligent agents embodied in the environment. Research into the concept of emergent narrative suggests that this kind of narrative offers opportunities for educational material to be presented within a compelling, interactive and immersive virtual environment (Louchart & Aylett, 2004). Louchart & Aylett investigated the computer role-playing games (RPGs) as they hypothesised that this game genre is likely to be potentially relevant to the development of an emergent narrative theory. They empirically studied three different types of RPGs: board RPGs[2], conflicting RPGs[3] and Live RPGs[4] in order to identify the patterns and the elements that influence the creation, development and unfolding of the emergent narrative. The idea of emergent narrative was applied in the VICTEC project. The project aims at building a computer-based system to help with anti-bullying education for children aged 8-12 in the UK, Germany and Portugal. FearNot! software was develop as a 3D application embodied with emergent narrative and synthetic characters in order to establish empathic relations

[2] "Board RPG is played with fictive characters, sometimes actually with board-sized models, and is organised as a campaign; the game is composed of several sessions and usually involves a quest with a group of largely cooperating characters. The interest of this genre lies in their episodic nature and the way they handle narrative events and character development." (Louchart & Aylett, 2004)

[3] "Conflicting RPG is a variant played with conflicting character goals and personalities over a short period in a single session and is of interest for its management of narrative tension and narrative set up." (Louchart & Aylett, 2004)

[4] "Live RPG is played in the real world in the same type of spirit as historical re-enactment, and is relevant for its management of narrative controls on a real-time basis." (Louchart & Aylett, 2004)

between a user and the characters when bullying scenarios were exposed (Aylett et al., 2005).

As suggested by Waraich (2002), in an educational context systems that use appropriately constructed pre-designed narratives have a number of advantages over those that use emergent narratives. Since emergent narratives rely on interpretations and actions of users, this can lead to some basic problems. For example, the story may not be coherent or some important events may not occur. The second example is likely to be a major concern for designers and developers of educational instructions. His suggestion is supported by the work of Plowman (1996; 1998). Plowman regards the design of hypermedia ILEs as offering a number of aspects that can support learning. For instance, learners can choose their own paths of interest. However, the design of the ILEs may also cause a problem for learners' cognition if the narrative structure is absent. Based on the literature, it was considered that the pre-designed linear narrative with limited branching points seems to be the most appropriate narrative structure for the design and development of an adventure-based educational game aiming to teach abstract knowledge (as can be seen from BAT (Waraich, 2004)). As a result, we were inclined to apply this kind of narrative when developing our game prototype based on the adventure game genre in order to use in this research.

### 3.4.3 Computer Games and Motivation

One reason that researchers and educators have been interested in incorporating computer games to learning is because they were considered as a great motivator. Players seem to be internally driven to play computer games and they can spend hours (or even days) in front of computers in order to complete the game's quest. As mentioned in section 3.2, early motivational researchers have proposed four characteristics which can be found in most intrinsically motivating learning environments: challenge, curiosity, fantasy and control (Lepper & Malone, 1987; Malone, 1981; Malone & Lepper, 1987). Computer games are likely to be the 'instructional artifact' that closely matches with these characteristics the most (Rieber, 1996). Furthermore, games provide clear goals to players and this can be considered as another characteristic that makes computer games so engaging (Prensky, 2001). The theory of flow (Csikszentmihalyi, 1990) has been widely discussed in recent research that focuses on creating a motivating computer-based system as the theory and motivation in learning seem to lend each other. Several analyses describe the pleasures in playing computer games as 'flow' experiences (e.g. Malone, 1980; Rieber, 1996;

Prensky, 2001). According to Prensky (2001), these pleasures and the experiences of flow are summarised as

> "In the flow state, the challenges presented and your ability to solve them are almost perfectly matched, and you often accomplished things that you didn't think you could, along with a great deal of pleasure. There can be flow in work, sports and even learning, such as when concepts become clear and how to solve problems obvious." (p. 124).

As discussed by Kirriemuir & Mcfarlane (2004),

> "The conditions likely to induce the flow state are characterized by Malone as:
>
> - the activity should be structured so that the player can increase or decrease the level of challenges faced, in order to match exactly personal skills with the requirements for action
> - it should be easy to isolate the activity, at least at the perceptual level, from other stimuli, external or internal, which might interfere with involvement in it
> - there should be clear criteria for performance; a player should be able to evaluate how well or how poorly (s)he is doing at any time
> - the activity should provide concrete feedback to the player, so that (s)he can tell how well (s)he is meeting the criteria of performance
> - the activity ought to have a broad range of challenges, and possibly several qualitatively different ranges of challenge, so that the player may obtain increasing complex information about different aspects of her/himself." (p. 14).

They also argue that there is a need to understand the deep structures of the game play experience that contribute to 'flow' and incorporate these into learning environments rather than aiming for an experience that superficially resembles leisure-based 'fun' activities. Waraich (2002) developed the system, BAT and tested it with students at the university level. The results show that the students were likely to feel motivated to learn through BAT. Waraich also tried to determine whether the students entered a flow state while using BAT by using interview method along with evidence from several sources. Four students were interviewed and one of them was reported to enter such a state but it was not clear whether the other three students entered the flow state. Nevertheless, his study can be regarded as an example that supports Kirriemuir & Mcfarlane's (2004) argument. Also, the connection between computer games and flow seems to be confirmed by Rieber (1996) as he mentions that the flow theory seems to relate best to self-regulated learning and fully focuses on adult's motivation; a computer game is an environment which combines both motivation and self-regulation in learning in a constructivist framework.

Recently, the term 'serious game' has been used widely; and it refers to a game developed using game technology and game design principles for a primary purpose (e.g. education or training) other than pure entertainment. Serious games can be similar to educational games, but are often intended for an audience outside of primary or secondary education. Serious games may be simulations which have the look and feel of a game, but correspond to non-game events or processes such as business operations and military operations. The games are intended to provide an engaging and self-reinforcing context in order to motivate and educate players. Other purposes for such games include advertisements[5] and use with medical professionals. Johnson et al. (2005) state that the goal of serious games is similar to that of the AIED community – to promote deep engagement with subject matter. They conducted a study centred around the question of what role artificial intelligence should play in serious games to promote learning with a high level of engagement. They discussed this issue in the context of the Tactical Language Training System (TLTS) which is a serious game developed for training military personnel to study Arabic language. The AI design was used to support the design of the system in order to promote instructive gameplay, to manage the challenge level of the user experience, to provide scaffolding when needed and to support users to reflect on their play and improve their skills. The TLTS was evaluated several times with representative learners and the evidence shows that the game format can motivate learners who will otherwise be reluctant to study a difficult language such as Arabic in the first place. However, the content that appears in the TLTS was planned to be developed further and as for the evaluation, many military training centres have volunteered to serve as test sites.

[5] Serious games developed for advertisements (sometimes, known as advergaming) refer to video games that are used to advertise a product, organisation or viewpoint. An example of advergaming is Millsberry.com; it is endorsing General Mills cereal by featuring their products on the website (Source: www.wikipedia.com).

## 3.5 Summary

As stated by Waraich (2002),

> "We suggest that there are parallels between the worlds of entertainment and education. A good educator needs to motivate her students to learn and must create experiences that will change their world-view in some way. Entertainers have a similar remit they must communicate their theme or message to the audience and need to understand how to engage and motivate them." (p. 55).

Based on this statement and the review of relevant literature described so far, we considered computer games as a potential medium that, if carefully designed, could offer new opportunities for learning. Also, they were considered to be capable of driving learners' motivation which is the pre-condition in an attempt to create a model of learners' motivation.

In chapter 2 we did a literature review on issues that relate to motivation and learning, specifically in the context of computer-based learning environments. In this chapter we examine several aspects of computer games that contribute to motivation in learning. From the review, we are able to specify the key theories of motivation and we also get a good understanding of the features that seem to be commonly found in an ILE developed within the educational game context (e.g. narrative/storyline). These were used as a basis for developing our preliminary motivation model which will be discussed in the following chapter.

# Chapter 4

# The Preliminary Causal Model

## 4.1 Introduction

As previously mentioned in chapter 1, the aim of this research is to investigate how learners are motivated when learning in a game-based learning environment. Specifically, we try to make progress in determining a motivational structure for the learners during the interaction with a game-based ILE and the way it might change during interaction. Our focus is on the relationships between learners' motivational characteristics and features of the game-based ILE. In this chapter the preliminary model of learners' motivation in the context of educational games is presented. The three major components of the model are specified: motivational variables, features of a game-based ILE and relationships between the first two components. The process of how the model was validated is discussed in the following chapters.

## 4.2 The Components of the Model

Cohen (1995) states that,

> "a datum represents the influences of many factors, although we generally don't know what all the factors are, how much they influence the datum or what to measure to estimate these influences. The purpose of exploratory data analysis is to develop and refine a causal model of data values. An early step in exploratory data analysis, therefore, is to sketch a causal model. This will serve as an agenda and a roadmap for exploratory work, as well as a notepad and a summary of suspicions and beliefs about the causal relationships among features represented by variables." (p. 18 – 19).

Cohen highlights that it is possible for a researcher to sketch a causal model before collecting data which can help him/her design an exploratory study to collect the data that he/she wants. Hence, a preliminary causal model showing the cause-effect relationship between the ILE features and a learner's motivational characteristics was developed. As explained in chapter 1, the term 'ILE features' was defined as the basic elements that make up an ILE whereas the term 'motivational characteristics' was defined as motivational variables of the learners which can be placed into two categories: trait (permanent characteristics) and state (transient characteristics) - adapted from de Vicente & Pain's (2002) motivation model. The choice of investigating this relationship was made as it was considered that strong relationships are likely to exist between the learner's motivational characteristics and the ILE features (this will be explained later in this section). Also, we considered that it is beneficial to provide a better cognitive account of what is going on when learners are motivated through the use of an ILE so we can seek to manipulate that in a sound ethical and pedagogical manner.

We mentioned in chapter 1 that a qualitative approach was considered to be used when modelling motivation. According to Bredeweg & Winkels (1998), in order to create a qualitative model for use in an ILE there are some main characteristics that need to be identified such as the structure of the model, the behaviour and the dependencies & causality. Therefore, the preliminary causal model was sketched and is shown in Figure 4.1.

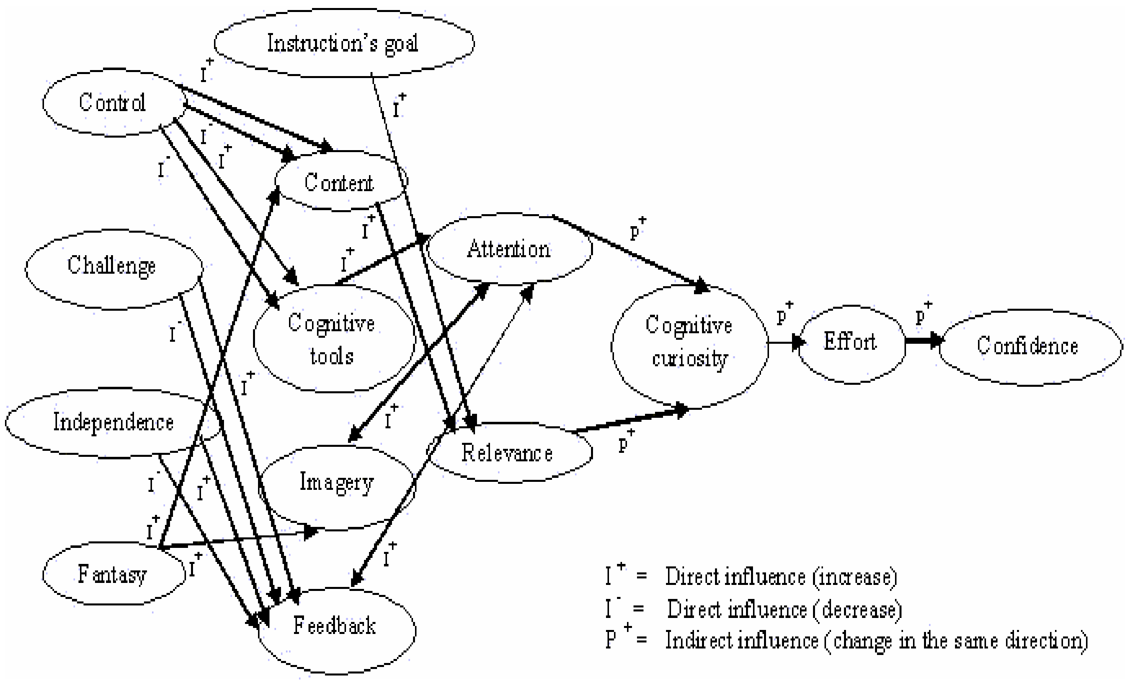


Figure 4.1: Causal model showing the relationship between a learner's motivation and ILE features

The model consists of nodes, used for representing the motivational characteristics and the ILE features, and links, used for showing the presumed dependencies among them. The model partly comes from our intuition (considering ourselves as a learner) about the plausible relationships between the learner’s trait characteristics and the components of the ILE, and is partly from a reading of the literature about the sensible relationships between the ILE components and the learner’s state characteristics and the relationships among the state characteristics themselves (Keller, 1979; 1983; 1984; 1987; 2001; Malone & Lepper, 1987). The model can be broadly divided into two major related parts: the motivational variables and the ILE components. However, we will consider this model in terms of three minor connected parts: trait characteristics, the ILE features and the state characteristics.

The arrows between traits and the ILE features demonstrate the direct influences of traits on the use of related ILE features, either increasing ($I^+$) or decreasing ($I^-$) the use of them; thus, the features should be able to adapt themselves according to a learner’s traits. Similarly, the arrows between the ILE features and states show the positive impacts of the features on the value of attention and relevance (increasing the value ($I^+$)) as a result of designing the ILE that contains such adaptive capabilities. The positive impact on attention and relevance will, then, lead to changes in the same direction ($P^+$) for the rest of the states in the model as can be seen from the arrows among the motivational states (attention, relevance – cognitive curiosity, cognitive curiosity – effort, effort – confidence).

### 4.2.1 The Motivational Variables of the Model

de Vicente (2003) developed a motivation model which consists of motivational variables that can be placed into two categories: trait variables, or more ‘permanent’ characteristics of the student, and state variables or more ‘transient’ characteristics. In his model four motivational variables (control, challenge, independence and fantasy) are categorised as traits whereas there are six variables which are categorised as states (relevance, confidence, sensory interest, cognitive interest, effort and satisfaction). His model is shown in Figure 4.2.

He explains that such a categorisation helps him to distinguish between the characteristics of the student that are not likely to change during an instructional interaction and those that are likely to change during the interaction. However, he states that his way in categorising these motivational variables is not the only possible way – the actual position of the variables under one of the two categories can be changed. Rather, the category in which a variable is placed gives an indication of the emphasis given to it in the model.

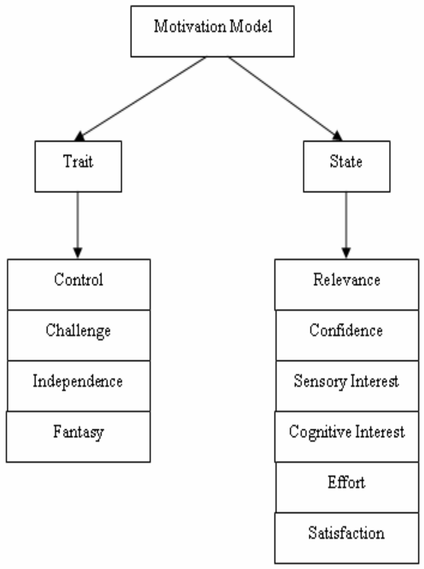


Figure 4.2: de Vicente's motivation model (reproduced from de Vicente, 2003, p. 47)

It was considered that his model seems to be suitable to apply with the context of this research since the model takes into account various relevant variables which are found in the literature regarding motivation in a game-based learning context such as control, challenge, fantasy and so on. However, some adjustments were made to the model, particularly the state variables, to make it more suitable to the research context. It was decided that 'cognitive interest' should be changed to 'cognitive curiosity' as the latter term, to us, is easier to understand. The variable 'sensory interest' was discarded from the model and the variable 'attention' was incorporated instead as it was considered that the notion of these two state variables are similar, but the notion of 'attention' seems to be more straightforward; also, it is the first requirement to be met in order for students to be motivated to learn according to Keller's (1984) ARCS model which is the model for motivational design of instruction. Another state variable which was dropped from the model is 'satisfaction' since it is defined as the overall feeling of goal accomplishment in de Vicente's (2003) model in which it was considered to be similar to the variable 'relevance' in our model.

As people seem to have different interpretations of the same term of a particular interest, it was considered that the definition of the motivational variables, as found in Figure 4.1, should be provided to prevent the problem of misinterpretation. These definitions are shown in Table 4.1. The majority of the definitions were adopted from de Vicente's, but some were added/changed based on our own perspectives towards the particular variables (attention and cognitive curiosity).

| Variable | Definition |
|---|---|
| Control | The degree of control that the student likes to have over the learning situation (i.e. does he/she like to select which exercises to do, in which order, etc. rather than let the instructor take these decisions?). |
| Challenge | The degree that the student enjoys being faced with situations that require great mental or physical effort during the instruction (i.e. does he/she like to try difficult exercises rather than the easy ones?). |
| Independence | The degree that the student prefers to work on his own, without asking others for help (i.e. does he/she prefer to complete the work by himself/herself, even if he/she finds some difficulties, he/she will try to solve them by himself/herself rather than asking help from others?). |
| Fantasy | The degree that the student appreciates environments that evoke mental images of physical or social situations not actually present (i.e. does he/she like the learning materials being embedded in an imaginary content or does he/she prefer just “the facts”?). |
| Attention | The degree to which the student’s interest is grasped by events – these events can range from simple unexpected events (e.g. a loud whistle) to mentally stimulating problems that engage a deeper level of curiosity (i.e. is he/she attracted to the presentation of instructional materials?) |
| Relevance | The degree to which the student’s important personal needs are met throughout the learning situation (i.e. does he think that the instructional materials are personally related to what he wants?) |
| Cognitive curiosity | The degree to which the student’s interest is aroused through the cognitive or epistemic characteristics of the task (i.e. regardless of the presentation issues, does the student find the task at hand cognitively appealing?) |
| Effort | The degree to which the student is exerting himself in order to perform the learning activities. |
| Confidence | The student’s belief in being able to perform the task at hand correctly. |

Table 4.1: Definitions of motivational variables (adapted from de Vicente, 2003, p. 46)

### 4.2.2 The ILE Features

As mentioned earlier at the start of section 4.2, the term ‘ILE features’ in this research was defined as the basic elements that make up an ILE. A number of sources (Bandura & Schunk, 1981; Malone & Lepper, 1987; Waraich, 2002; 2004; Quinn, 2005; Habgood & Overmars, 2006) were reviewed in order to specify these elements and some common features were drawn which are: instructional goal, content, cognitive tool, imagery and feedback. The definitions of these features are shown in Table 4.2.

| ILE features | Definition |
|---|---|
| Instructional goal | The specific goal of any particular instructional episode |
| Content | The domain knowledge in a particular instructional episode which is aimed to be delivered to students |
| Cognitive tool | The tool created to aid students in learning from a particular instructional episode |
| Feedback | Responses containing specific instructions based on students’ performance |
| Imagery | The graphical elements, both visual and audio, presented in a particular instructional episode |

Table 4.2: Definitions of ILE features

According to the literature, the presence of an explicit goal is likely to play an important role in making simple computer games more appealing (Malone & Lepper, 1987). Bandura & Schunk (1981) show that by simultaneously providing both proximal and distal goals may prove to be effective motivational devices. Also, the work by Waraich (2004) show that an ILE which is carefully designed and provides clearly articulated goals like BAT (Binary Arithmetic Tutor) can motivate students to learn abstract domains such as binary arithmetic and logic gates. Based on this evidence, it was decided that the 'instructional goal' seems to be the fundamental element when developing an ILE and thus, it was included as one among several ILE features of our model.

According to the definition shown in Table 4.2, it appears evident that 'content' is also another fundamental element that constitutes an ILE as it refers to the knowledge embedded in an ILE which is delivered to students similar to that given by a human tutor.

The notion of a 'cognitive tool' is another element that is likely to be found in most ILEs. It was defined as the tool created to help students learn within a particular learning environment. A number of research papers were reviewed and according to the literature, the tool seems to appear in various forms which are more or less obvious to the students. For instance, Waraich (2002; 2004) developed two prototype ILEs: MOSS (Map reading and Ordnance Survey Skills) and BAT (Binary Arithmetic Tutor) aiming to teach binary arithmetic and logic gates, respectively. In both prototypes a character acting as a tutor was used. It was considered that the use of the tutor character in the ILEs is a form of cognitive tool as students seem to learn directly from such a character. A less obvious use of cognitive tool can be seen in the MENO (Multimedia, Education and Narrative Organisation) project. In this project the Galapagos CD-ROM was created as a research tool to explore the role of narrative in the design of Multimedia Interactive Learning Environments (MILEs). Galapagos aims at teaching the principles of natural selection using Darwin's experiences in the Galapagos Islands. Three versions of Galapagos were created with systematically manipulating specific design features; however, in all versions a Notepad was embedded in order to be used by students to write the answer to the task. It seems that the Notepad, to some extent, may be regarded as a cognitive tool as it is the system feature which was created to visually help the students form their answers or in other words, it is the cognitive representation of what the students learned.

'Feedback' is an element which was considered to be crucial in the game-based context. Quinn (2005) considers feedback as pedagogical support in educational games which needs to be carefully considered as he suggests that

> "Although it is still a matter of some debate about just when feedback should be given, there should be no debate that when the learner receives feedback, it should

specifically refer to the framework and the learner's performance and yet remain believable in the context of the story." (p. 142).

Furthermore, it is necessary to consider how much of this kind of support should be provided. It was considered that feedback can take various forms such as reward (positive feedback), punishment (negative feedback) and clues (guided feedback). According to Habgood & Overmars (2006), rewards are very important for sustaining a player's interest in a game and they can be: a congratulatory message, a bonus score and so on. On the other hand, punishments can be regarded as feedback given when a player's actions violate the principles of the underlying concept and they can take the form of a message that indicates a mistake, a decrease in score and so on. Clues, however, are a different form of feedback as their aim is to help a player solve the puzzles/tasks in a game and as a result, they are likely to contribute to constructivist learning.

The last major element which was considered to be basically found in a game-based ILE is 'imagery' which, according to the definition table, refers to the audiovisual elements presented in a particular instruction. If a game ILE does not contain this element, then, definitely, it will not be often regarded as a game.

### 4.2.3 The Relationships of the Motivational Variables and the ILE Features

As mentioned at the beginning of section 4.2 of this chapter, we chose to investigate the relationship between motivational characteristics of learners and features of an ILE because to us, there seems to be strong relationships hidden between them. We consider that a learner's traits can influence the use of the ILE features directly either increasing or decreasing the use of them and thus, the ILE components should be able to adapt themselves according to the traits of the learner in order to suit their learning preferences. An ILE that contains adaptive capabilities can impact on the learner's motivational states positively and this is likely to contribute to motivation in learning. Our consideration conforms with the motivation model proposed by de Vicente (2003) as the model is divided into two categories: traits and states. He states that "the information about trait characteristics would allow an Affective Tutor to individualise the instruction based on student prototypes, while the state variables would allow an Affective Tutor a more detailed individualisation based on changes during interaction with the system." (p. 45). Therefore, it is likely that there exist relationships among traits, an ILE and states; however, the nature of these relationships is not clear. Nevertheless, we have sought to sketch out the sensible and plausible relationships between these two types of motivational characteristics and the features of an ILE from our intuition based on a reading of the literature. These relationships are also shown in Figure 4.1.

According to Figure 4.1, control is the trait characteristic which was considered to have an influence on the use of two ILE features: content and cognitive tool. Malone & Lepper (1987) state that “One explanation for why people find computer games so captivating is that they give their players a powerful sense of control.”. It appears therefore that a game ILE can provide this sense to learners by allowing them to have control over some parts of the game such as story (content) or characters (cognitive tool). On the other hand, challenge and independence are the trait characteristics which were considered to have an influence on the feature: feedback. As also stated by Malone & Lepper, activities that offer some challenge are likely to stimulate the greatest intrinsic motivation and there are some characteristics of an activity, as agreed by a number of theorists, that are required to provide a challenge to learners; for example, the activity must provide goals in which the goal attainment is uncertain and also, it should provide performance feedback regarding the goal attainment. It was considered that in a game-based learning environment performance feedback such as praise given when the learners complete a task successfully or direct/guided feedback given when they make a mistake in the task, is likely to be able to offer a reasonable level of challenge to the learners. Keller (1983) refers to independence as the characteristic that relates to the perceived feeling of requiring or not requiring the tutor’s help in order to accomplish the instructional task. Based on this definition, it is quite clear that feedback is related to the independence characteristics of learners as it can be seen as help in which the learners can choose whether they want to get it when performing the task in the game ILE. Fantasy is the final trait characteristic which was considered to have an effect on the features: content and imagery. As suggested by Malone & Lepper (1987) once again, fantasy is obviously important in several kinds of intrinsically motivating activities such as computer games, television and so on, and they define a fantasy environment as one that evokes mental images of physical or social situations which are not actually presented. Based on their definition, it was considered that a game ILE in which its storyline and imagery are carefully designed is likely to be able to evoke learners’ mental images of the domain knowledge embedded in the game environment.

Apart from being influenced by the trait characteristics of a learner, the features of a game ILE can also affect the state characteristics of him/her. Attention and relevance are the first two motivational states which were considered to be affected; attention was considered to be affected by the features: cognitive tool, imagery and feedback, whereas relevance was thought to be influenced by the features: instructional goals and content. According to Keller’s (1984; 2001) ARCS (Attention, Relevance, Confidence and Satisfaction) model, attention is the first requirement which should be obtained and sustained in order for a learner to be motivated. Tactics that may be used to gain the student’s attention range from simple unexpected events such as a loud whistle, to mentally stimulating problems that engage a deeper level of attention. Following these tactics, it seems that imagery can be regarded as the feature which can be used to create those simple unexpected events in order to gain the learner’s attention whereas cognitive tool and feedback can be viewed as the feature that is likely to be used for mentally stimulating the deeper attention level. Relevance is the second requirement in ARCS that should be built as a learner is likely to be motivated to learn if he/she believes that the instruction is related to his/her needs. In order to create this belief, it was considered that the content of the game should be connected to the learner’s important goals as relevance results from connecting the content of instruction to important goals of the learner, their past interests and their learning styles (Keller, 2001). Furthermore, in order for the content to be connected with the learners’ goal, the game instruction’s goals should be set to be used as a roadmap for the design and development of the game content.

Cognitive curiosity is the motivational state which was considered to be affected by attention and relevance. Malone & Lepper (1987) hypothesised that “people have a cognitive drive to bring “good form” to their structures and that instructional environments can stimulate curiosity by making them believe that their existing knowledge structures are not well-formed”. It was considered that in order for this motivational state to occur, the learning environments should be designed in such a way that make the learners think that their knowledge in a specific domain is not enough and that they need to learn more. To achieve this, it seems that the learning environment must firstly gain the learners’ attention and be able to establish the goal in learning. As a result of this, it looks like cognitive curiosity is the state that comes after attention and relevance.

Sequentially, effort is the motivational state which was considered to be impacted by cognitive curiosity. According to Keller’s (1979) theory of motivation, performance and instructional influence, effort refers to whether an individual learner is engaged in actions aimed at accomplishing the task and is influenced by three broad variables: motives (values) which refer to how individual needs and beliefs relate to choices of action, expectancy which refers to how personal expectancies affect behaviour and the motivational design and management of instruction. Based on his theory, if the learning environments are successful in making the learners believe that their existing knowledge is not well-formed (motives) it will evoke the feeling of cognitive curiosity, it is then likely that they will expect to gain more knowledge (expectancy) from the instruction and with the design of instructions in such a way that engages the learners' actions, it seems that these can influence the use of effort. As a result of this, it seems sensible to believe that effort comes after cognitive curiosity.

Confidence is the last motivational state in our model that occurs before the learners feel motivated. It is the motivational state that was considered to be affected by effort. Based on ARCS (Keller, 1984; 2001), confidence is the third requirement and refers to the establishment of positive expectancies for success; he also suggests that confidence can be easily built by making the objectives clear and providing examples of acceptable achievements; however, there is an issue that one's overall confidence can be improved if the learners attribute success to personal effort or ability, but if they believe that success was due to external factors such as luck, then confidence in one's skills does not seem to increase. According to this, it is likely that effort is the state that comes before confidence as Keller's model accounts the improvement of one's confidence based on the attribution of effort.

## 4.3 Summary

Our preliminary causal model presents a set of the main characteristics for student motivation and the major features of game-based learning environments, and the relationships among them. While these relationships are based on a reading of the literature, they ultimately need to be empirically justified.

In the next chapter we describe how computer-based research instruments are designed and developed to use them in the exploratory study. This led to the collection of students' motivational data as we aimed to validate the model.

# Chapter 5

# Computer Based Research Instruments: Design and Implementation

## 5.1 Introduction

One may doubt why we chose to develop the game research instrument on a computer-based basis instead of creating a paper-based one. To make it clear, we need to refer to the aim of the research as already mentioned in chapter 1. This research aims to model motivation of learners using an ILE, particularly in the context of an educational game and as a result, the game is best built based on a computer in order to make it fit with its potential future use within an ILE. However, one may question further why choices of existing computer-based educational games were not of interest to us. It was considered that using an existing game could save time as we then do not need to create a new one. However, we anticipated problems with modifying an existing game to make it suitable for our needs. In addition, I have experience in teaching databases and from this experience students seem to have problems in understanding the conceptual knowledge of the subject, specifically, the Entity Relationship Modelling (ERM) concept. Thus, we considered that creating a game to teach this concept may contribute to the area of computing science.

In this chapter we describe how we constructed the software instruments that were used in the field study. Two software prototypes were developed: the game prototype – Alex’s Adventure, and the computer program – MoRes. The game prototype is described in two separate, but intertwined phases: design and implementation phase, starting with the design of the storyline, how it was mapped to our preliminary model and how we turned these requirements into detailed specifications of the game. Then, we move on to explain about how the game was implemented to match the different trait characteristics. A glimpse of how the exploratory study was conducted is also provided; however, a detailed description of the study is left for chapter 6. A brief overview of how MoRes was created including its functionalities is described before concluding with a chapter summary.

## 5.2 The Domain Knowledge

The domain knowledge that we aimed to teach was Entity Relationship Modelling (ERM) concepts. This domain was our focus because the concept of ERM is complex. Based on the author's experience in teaching an introductory database course for two years, students seemed to experience similar problems in: (1) identifying entity types, (2) distinguishing entities from attributes and so on. Because of its complex nature, this can negatively affect a learner's motivation in learning. Even though there are several support tools created to help students such as DBTool (Lim & Hunter, 1992), ERM-VLE (Hall & Gordon, 1998), COLER (Constantino-Gonzalez & Suthers, 2000), KERMIT (Suraweera & Mitrovic, 2002), none of them are developed in the form of an educational game. We considered that building an educational game aiming to teach this domain would be beneficial to students in terms of aiding their understanding of the concepts and attracting them to learn.

## 5.3 The Computer Based Research Instruments

As reported above, two separate systems were developed: a game prototype, Alex's Adventure and a computer program, MoRes. The game prototype was developed to teach concepts regarding entity and attribute in Entity Relationship Modelling in a hopefully-motivating learning environment. The program, MoRes, was developed in order to get the values of trait characteristics and of initial motivational states from a particular learner and to infer the values of the other motivational states that appeared in the model. It is also capable of inferring the motivation of the learner towards the game at the end of the interaction session. At this stage, we decided not to build a single system that contained both functionalities as the two main functions are different in nature. To retrieve the motivational data from a learner, electronic questionnaires were planned to be used and it was considered that the interfaces developed for the questionnaires would be different from those of the game prototype. Although some tools such as Macromedia Flash can be used for developing these two kinds of interfaces, it was considered to be a time-consuming task as I may have to spend a lot of time on learning how to use it. What I was looking for was a tool that could be used to create the system rapidly. For this reason we chose to develop two separate systems as I had experience in developing a small computer-based application using Visual Basic and Microsoft Access before. As a result, these software tools were used when developing the computer program – MoRes. As for the game prototype, it was considered that it seems sensible to use existing software developed specifically for creating computer games since it contains features and functions which can be used to build the game.

## 5.3.1 The Game Prototype: Alex's Adventure

In this section we describe the potential methodology for designing and developing game-based learning environments. The stages and steps in designing and implementing our game prototype are also explained.

### 5.3.1.1 Methodology for Designing and Developing Game Based Learning Environments

There are several models that were proposed for the design and development of computer based learning environments that are based on games such as Prensky's (2001) model, the Game Object Model (Amory et al., 1999) and Quinn's (1994) model. However, according to the assessment of these models done by Waraich (2002), it seems that the most clearly defined is Quinn's as it has a clear basis in existing theory whereas Prensky's model is based on an analysis of commercial educational games development. Amory's model seems to focus more on the techniques used for developing an educational game and the model does not treat narrative as the focus of the design. It was considered that Quinn's model is likely to be suitable to adopt as a methodology used for designing our game prototype since the model is likely to combine the principles of interface design, cognitive science and instructional design together. Quinn (2005, p.132) proposed a methodology for engaging design of a learning game which is outlined in Table 5.1.

Quinn explains that in the analysis phase the main instructional goals and the potential audience including their motivations and interests should be identified. The information from this stage is then passed into the specification phase in which an overall specific design needs to be settled. The key issue in this stage is to think about building a situation in which a learner can be faced with a compelling experience and thus, a storyline, setting and theme should be elaborated in detail. In addition, the support for learning (pedagogical support) and how to incorporate it into the game must be considered along with the appropriate mapping between the actions of the learners and the learning objectives. Once the story and interface are created, a way to populate the game decisions is needed. For the mini-scenario model[1] and the linear scenario model, the decision storyboard is sufficient; however, for the contingent scenario[2], all branches and how they connect should be identified. The output of the specification stage will then be passed on to the next stage – the implementation phase. However, Quinn does not provide any details about techniques which may be useful for the development process. After the game prototype is developed, the final step is to evaluate it in terms of usability, educational effectiveness and engagement.

| **Learning Game Design Stages and Steps** |
|---|
| **Analysis** |
| • Determine target performance |
| • Determine learner characteristics |
| • Determine learner interests |
| • Establish matrices |
| **Specification** |
| • Situate the task in a model world |
| • Elaborate the details |
| • Incorporate underlying pedagogical support |
| • Map learning to interface |
| **Implementation** |
| • Prototype |
| **Evaluation** |
| • Test for usability |
| • Test for educational effectiveness |
| • Test for engagement |

Table 5.1: Stages and steps for learning game design (Quinn, 2005, p.132)

#### 5.3.1.2 The Analysis Phase

Two main goals were specified for the design and development of our instructional game. The first goal is to teach some concepts in ERM, specifically, the concepts about entities and attributes as the aim of supporting learning seems to be the first priority for every educational game instruction. The second goal is to provide the feeling of ‘hard fun’ (Quinn, 2005) to learners since they will be offered a new and captivating environment to learn some ERM concepts.

Apart from the instructional game’s goals, the potential user group was also identified. Computer science students were chosen as the game is likely to be more

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1 The term ‘mini-scenario model’ refers to the scenario of a computer game which is designed according to traditional instruction, but the practice items are couched in contextual language instead. The scenario will have traditional introduction, concept, and examples, and contexts for the decisions (so that there is a theme that sets the stage for the choice). For the practice, there is a set up of the context, an action taken by the learner, and feedback, all set within the context. The context surrounds the individual decision; however, it is an improvement over knowledge test questions (Quinn, 2005, p. 77 – 78).

2 The term ‘contingent scenarios’ refers to branching scenarios, where a player’s choices do have consequences, and what he/she sees is contingent upon what choices he/she makes (Quinn, 2005, p. 95).

relevant to this target group. Moreover, they seem to gain more benefits from using the game.

### 5.3.1.3 The Specification Phase

It was considered that a major step in creating the game prototype for our study is to develop a story that contains all ILE features as shown in our preliminary model in the previous chapter. Also, these features were designed not only to be embedded in the story, but also to take into account the relevant trait characteristics of a player. Some of these features are represented in the story as a character. For example, feedback given by the character involved in the game towards the player's action was designed to be challenging to suit the characteristics of learners who like a high challenge. Our aim is to demonstrate that creating the storyline including the characters according to the above characteristics will provide some information about the relationships between the motivational characteristics of learners and the ILE features which can then be used to examine our preliminary model.

Waraich (2002) suggests that in an educational game context a suitably constructed 'pre-designed' narrative has a number of advantages compared with systems that try to use emergent narratives. A fundamental problem with emergent narratives is that firstly, they depend on appropriate actions or 'events' occurring to create a sensible narrative and secondly, the events need to be interpreted by the 'reader' in order to create a story. There may be a case in which the events are not likely to occur, but if they do, they may not make a coherent story. Since the domain knowledge that we aim to teach is rather conceptual and quite complex in nature, it was considered that a pre-designed narrative seems to be more suitable as we do not want the knowledge structure to be ruined by the story.

A linear narrative with a branching structure, as illustrated in Figure 5.1, was employed as a basis for the development of the storyline of our game prototype. As Waraich mentions, this structure is very common in the design of computer games and we considered that the structure is suitable for our domain.

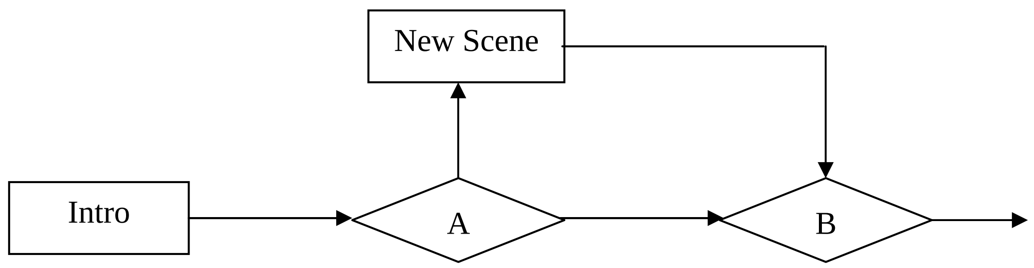


Figure 5.1: Linear narrative structure with branching scenes (reproduced from Waraich, 2002, p. 122)

In this structure the plot of the story is constructed along syntagmatic scenes[3] and branches can occur from this basic structure; however, they will always lead back into the linear narrative.

#### 5.3.1.3.1 Designing the Premise of the Story

When creating a story, the most important thing is likely to be the designing of the central idea (premise) including its plotline. Also, the distribution of teaching points along the plotline should be carefully designed. A storyline for our game prototype was created taking into account those aspects and the main theme involves a Player Character (PC) called Alex who tries to help a character called Emma recover from serious illness by taking drugs prescribed by a cold-hearted doctor, Dr. de Ville. Alex has to complete two tasks with the help of a few Non-Player Characters (NPC) in order to earn money for buying drugs. The tasks encapsulate the concepts of entity and attribute in ERM and these concepts are revealed later via a character called Mushyman.

#### 5.3.1.3.2 Mapping the Story to the Preliminary Causal Model

According to the preliminary model presented in chapter 4, five ILE features were considered to have relationships with the motivation of learners. These features are embedded in various forms of story elements as shown in Table 5.2.

[3] The term 'syntagmatic scenes' is the term used in film and television and can be referred to the scenes that are sequentially related to others.

| ILE Features | Represented Elements in the Storyline |
|---|---|
| Instructional Goal: Support Learning | Alex (PC) completes all tasks |
| Instructional Goal: Provide Fun | Alex (PC) brings back the drugs for Emma |
| Content | Tasks given by Dr de Ville (NPC) |
| Cognitive Tool | Mushyman (NPC) |
| Imagery | Graphical elements: both visual graphics and audio graphics used in the game |
| Feedback | Responses from Mary and James (NPC) with regards to Alex's performance in doing the tasks |

Table 5.2 The ILE features and their represented elements in the story

Generally, the instructional goal refers to the specific goal of any particular instruction. In our case, the game instruction aims at teaching the concepts of entity and attribute in ERM (goal: delivering knowledge) and offering a fun experience (goal: providing fun) to a learner. The feature 'content' refers to the domain knowledge which the learner has to master and it was designed to appear as the tasks in the game which the learner has to complete; we planned to create two tasks when developing the game ILE. The third ILE feature is a 'cognitive tool' which we defined as a tool created to aid the learner to learn the desired knowledge. The character called Mushyman was designed to represent this tool and it will show up when Alex finishes each task to provide a summary of the domain knowledge. The next feature is 'imagery' which refers to the graphical elements, both visual graphics and audio graphics, used in the game. Feedback is the last ILE feature which was defined as responses given back to the learner with regards to his/her performance and it was designed to be represented by two characters called Mary and James.

We also considered that these story elements should be designed not only to map to these ILE features, but also to offer relevant motivational characteristics to the learner as can be seen from Table 5.3.

<table>
<tr><th>Relevant Traits</th><th>Represented Elements in the Storyline</th><th>Relevant States</th></tr>
<tr><td rowspan="2">-</td><td>Alex completes all tasks</td><td rowspan="9">Attention<br>Relevance<br>Cognitive Curiosity<br>Effort<br>Confidence</td></tr>
<tr><td>Alex brings back drugs for Emma</td></tr>
<tr><td rowspan="2">Control</td><td>Tasks given by Dr de Ville</td></tr>
<tr><td>Mushyman</td></tr>
<tr><td>Challenge</td><td>Responses from Mary and James with regard to Alex's performance in doing the tasks</td></tr>
<tr><td>Independence</td><td>Responses from Mary and James with regard to Alex's performance in doing the tasks</td></tr>
<tr><td rowspan="2">Fantasy</td><td>Tasks given by Dr de Ville</td></tr>
<tr><td>Graphical elements, both visual graphics and audio graphics, used in the game</td></tr>
</table>

Table 5.3: The represented story elements of the ILE features and the relevant motivational characteristics

As can be seen from the table, four selected traits are of interest to us: control, challenge, independence and fantasy. The first trait is 'control' and the story elements designed to offer control are the tasks given by Dr de Ville and the character –

Mushyman. A learner is allowed to have a certain degree of control over some parts of the tasks and over Mushyman by offering him/her a choice in receiving an explanation about the knowledge embedded in the tasks. However, this also depends on the level of control which may vary from one learner to another and as a result, learners who prefer to have high a high level of control in a learning environment will be offered these choices whereas learners who prefers to have low control will not receive these choices. ‘Challenge’ is the next trait and the element in the story that offers this variable is responses given by Mary and James about Alex’s performance in doing the tasks. In addition, the responses from Mary and James were also designed to provide ‘independence’ for each learner. A learner is able to choose whether to receive the feedback from these characters in case he/she does something wrong in the tasks; this is based on the assumption that each learner is different in the level of need to succeed by himself/herself. If a learner chooses to get the feedback when he/she makes some errors in the tasks, the feedback given will differ according to his/her preferred level of challenge; the learner who likes to learn in a challenging situation will be given guided feedback which is the feedback that does not tell directly what went wrong; rather, it is the feedback that aims at stimulating the learner to think and discover the errors by himself/herself; on the other hand, the learner who prefers to learn in a less challenging situation will receive direct feedback instead. The last trait in the model is ‘Fantasy’ and the element which was designed to offer this variable is the tasks in the game and the audiovisual graphics used in the game. We were inclined to assume that using the metaphor to represent the domain knowledge along with the use of graphical elements will allow a learner to sense a high fantasy characteristic in our game ILE.

#### 5.3.1.3.3 Building the Game Model

So far, we have described the requirements needed to create our game ILE. The domain knowledge of the game was chosen and also, the potential user group and the game instruction’s goals were specified along with the premise of the story and how the story represents the ILE-features part of the preliminary causal model. It was considered that the next step was to turn all these requirements into the game model which contains detailed specifications of the game. These specifications are:

- the complete storyline in which the learning activities are set up alongside the characters which appear in the game in order to provide explanations of the knowledge/giving sources of feedback and to create a flow to the story
- the functionalities of the game such as the interactivity (events-actions)

- controls used in the game
- rewards and punishment

The storyboarding technique[4] was employed for building the game model. As suggested by Quinn (2005), this technique is appropriate for use with both the mini-scenario model and the linear scenario model (the model adopted for our game). With this technique we ended up with the low-tech design materials which were used as an input for the next phase: the implementation phase.

#### 5.3.1.4 The Implementation Phase

A game prototype was developed using Game Maker version 6.1. This tool was chosen because it allows rapid development and is easy to use for beginners who try to build a computer game for the first time. Furthermore, the tool is well supported; many free resources can be downloaded from the internet and there are internet forums and online tutorials in which game developers can seek support.

Since the game prototype was planned to be developed separately from the computer program that included the electronic questionnaires as previously described at the beginning of section 5.3, several versions of the game prototype were developed according to the combinations of learners' trait characteristics. We chose to develop several versions of the game rather than one single version that can adapt itself according to the learners' traits as it was considered to be technically easier and save time used for doing the programming task.

According to the preliminary model, four selected traits are of interest to us: control, challenge, independence and fantasy. However, only three trait variables (control, challenge, independence) were chosen to create the combinations as their values were considered to vary from one learner to another whereas 'Fantasy' was considered to be the trait variable in which its value is likely to be high in this context. We limited the values of each of those three trait variables to two (high and low) values rather than three (high, medium and low) as these two values are at the opposite end and thus, we could develop two types of game that are obviously different: one that is likely to suit with the high-value trait characteristics and one that is likely to suit with the low-value trait characteristics. Also, the value 'medium', in our view, is difficult to interpret

[4] The 'storyboarding technique' is often used in the film industry and is adopted as an instrument used for designing computer games. The technique uses sequenced frames in order to illustrate the designer's idea of plots, characters and settings which will appear in the game.

as our interpretation of this term may not be the same as the interpretation of learners. Given that there are two values for each of those three trait variables, there will be eight combinations of learners' trait characteristics. These combinations are shown in Table 5.4.

| Trait Variable | Combination | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Control | L | H | L | L | L | H | H | H |
| Challenge | L | H | L | H | H | L | L | H |
| Independence | L | H | H | L | H | L | H | L |

Legend: L = Low
H = High

Table 5.4: Eight combinations of learners' trait characteristics

Based on these combinations, four versions of the game prototype were developed. These games were created according to the low-tech (paper-based) materials which were the result of the design process. The specifications of these four versions of the game are displayed in Table 5.5, Table 5.6, Table 5.7 and Table 5.8.

| Trait Combinations | Trait Characteristics | ILE Features | Game Specifications |
|---|---|---|---|
| 1 & 3 | Low Control | Content | Cannot choose a storehouse/a wagon to start working with |
| | | Cognitive Tool | Cannot choose not to receive explanations (given by Mushyman) about the knowledge embedded in the tasks |
| | Low Challenge | Feedback | Direct feedback |
| | Low/High Independence | | Can choose whether to receive feedback given by Mary and James when making errors in the tasks |
| | | Imagery | Yes<br>(Graphical elements, both visual and audio graphics) |

Table 5.5: The specifications of the first version of the game: Alex's Adventure 1.0

| Trait Combinations | Trait Characteristics | ILE Features | Game Specifications |
|---|---|---|---|
| 2 & 8 | High Control | Content | Can choose a storehouse/a wagon to start working with |
| | | Cognitive Tool | Can choose not to receive explanations (given by Mushyman) about the knowledge embedded in the tasks |
| | High Challenge | Feedback | Guided feedback |
| | Low/High Independence | | Can choose whether to receive the feedback given by Mary and James when making errors in the tasks |
| | | Imagery | Yes<br>(Graphical elements, both visual and audio graphics) |

Table 5.6: The specifications of the second version of the game: Alex's Adventure 2.0

| Trait Combinations | Trait Characteristics | ILE Features | Game Specifications |
|---|---|---|---|
| 4 & 5 | Low Control | Content | Cannot choose a storehouse/a wagon to start working with |
| | | Cognitive Tool | Cannot choose not to receive explanations (given by Mushyman) about the knowledge embedded in the tasks |
| | High Challenge | Feedback | Guided feedback |
| | Low/High Independence | | Can choose whether to receive feedback given by Mary and James when making errors in the tasks |
| | | Imagery | Yes (Graphical elements, both visual and audio graphics) |

Table 5.7: The specifications of the third version of the game: Alex's Adventure 3.0

| Trait Combinations | Trait Characteristics | ILE Features | Game Specifications |
|---|---|---|---|
| 6 & 7 | High Control | Content | Can choose a storehouse/a wagon to start working with |
| | | Cognitive Tool | Can choose not to receive explanations (given by Mushyman) about the knowledge embedded in the tasks |
| | Low Challenge | Feedback | Direct feedback |
| | Low/High Independence | | Can choose whether to receive feedback given by Mary and James when making errors in the tasks |
| | | Imagery | Yes (Graphical elements, both visual and audio graphics) |

Table 5.8 The specifications of the fourth version of the game: Alex's Adventure 4.0

It was planned that when conducting the field study, each participant would be assigned to play one of these four versions of the game depending on his/her trait characteristics. After finishing playing the game, he/she would be asked to report the value of his/her motivational states towards different features in the game including his/her overall motivation at the end of the game. If the overall motivation were reported to be low, the participant would be asked to play the adjusted version of the game which would be likely to be more motivating for him/her. As a result of this, another four versions of the game prototype were developed to be the adjusted versions of the four original versions described earlier. These adjusted versions contain some improvements in the imagery[5] and were named: Alex's Adventure 5.0 (created based on Alex's Adventure 1.0), Alex's Adventure 6.0 (created based on Alex's Adventure 2.0), Alex's Adventure 7.0 (created based on Alex's Adventure 3.0) and Alex's Adventure 8.0 (created based on Alex's Adventure 4.0), accordingly.

[5] There are three improvements made to the imagery used in the adjusted version of the game. The first improvement is that different colours are used for different chests that appear in the task. The second improvement is that the process of moving the right chest to the right storehouse/wagon is more visible. The last improvement is that when the participant finishes doing each task, fireworks will appear as a reward. These improvements can be seen from the screen capture of Alex's Adventure 6.0 as shown in Appendix A.

The screen captures of the game interfaces are shown in Appendix A. However, as the scenes of these four versions of the game are similar only the screen captures of Alex's Adventure 1.0, Alex's Adventure 2.0 and Alex's Adventure 6.0 are shown as there is an obvious difference between the first two versions (some branching scenes were created in Alex's Adventure 2.0) whereas the latter is the adjusted version of Alex's Adventure (all four adjusted versions were amended in the same way).

### 5.3.2 The Computer Program: MoRes

MoRes is a computer program developed using Visual Basic version 6.0 and Microsoft Access 2003. It was created to be a prototypical program that implemented our preliminary model of motivation. The program contains three major functionalities:

- to acquire the value of trait characteristics (control, challenge, independence and fantasy) from a student and to assign the version of the game that is likely to suit him/her
- to obtain the value of initial motivational states (attention and relevance) from the student after he/she finished playing the game and to infer the values of the other motivational states (cognitive curiosity, effort and confidence) as they chronologically appeared in the preliminary model.
- to infer the motivation of the student towards the game at the end of the interaction session

In the case that a student reports not to be motivated at all at the end of the game, MoRes will ask him/her to play the adjusted version in an attempt to engage him/her in learning from the instructional game. The screen captures of MoRes's interfaces are shown in Appendix A. However, the limitation of MoRes is that it was created on an ad hoc basis. This may lead to some discrepancies between the value of the motivational states inferred by MoRes and those reported by students using paper-based research instruments. Nevertheless, it was considered that by analysing the motivational data received from various sources, the preliminary model that was implemented in MoRes could be finally revised in a sensible way.

## 5.4 Summary

In this chapter we have described the design and the implementation of Alex's Adventure, an educational game prototype aiming to teach the concepts of entity and attribute in Entity Relationship Modelling (ERM) in a motivating environment. Likewise, there was a discussion about MoRes, a computer program developed in order to get the value of trait and initial state variables from a student, to infer the value of the other state variables as they chronologically appeared in the preliminary model and to infer the motivation of the student towards the game at the end of the interaction session.

By developing Alex's Adventure, we created an instrument which was supposed to be motivating for students. As for MoRes, we expected that it would be a tool that could select the game which was likely to suit the different learning preferences of a particular student and was capable of extracting and inferring his/her motivational data.

Both Alex's Adventure and MoRes were used in our field study and by using Alex's Adventure and MoRes in this fashion, we prepared a hard-copy version of a retrospective self-report and a questionnaire in order to extract the motivational characteristics of the students during and after their interaction with the game. These motivational data were analysed in order to provide us a better view of how one was motivated within the game-based learning environment. A description of how the field study was conducted is given in chapter 6 whereas a description of the data analysis is presented in chapter 7.

# Chapter 6

# Methodology

## 6.1 Introduction

To validate our preliminary causal model shown in chapter 4, a study needed to be designed to extract the motivational values of learners during an interaction with our educational game and to gather other information which we regarded as useful in the data analysis phase.

In this chapter we describe how the study was designed, starting with the issues relating to the materials used in the study and the selection of the participants of the study (see sections 6.2 and 6.3, respectively), followed by a description and justification of the methodology selected for the study in section 6.4. In order to answer our research questions[1] we also discuss the methodology of the data analysis in section 6.5; we set out to examine the following issues (a) the approach used for doing data analysis – why using a qualitative approach as opposed to a quantitative approach (b) the strategy used in doing qualitative data analysis, case study analysis in particular (c) the number of selected cases and the criteria used for selecting each case

## 6.2 Materials

It was considered that the number of different initialisations of the model can vary from a handful to almost infinite. For practical purpose, we can only manage a small number. Thus, eight versions of the game, Alex's Adventure, were developed in order to perform this study. As previously discussed in chapter 5, we decided to create eight versions of the game rather than one single version because it seemed to be technically easier and helped save time during the programming task. The number 'eight' came from the combinations of possible values provided by learners for three trait characteristics:

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[1] Two research questions were specified for this thesis (1) Given a specific context for a learning environment, can we determine a motivational structure for learners during their interaction? (2) Can we make progress in determining the way this might change during the interaction?

control, challenge and independence (more details on this appear in section 5.3.1.4). The game – Alex's Adventure – aims at teaching ERM concepts in databases, specifically entity and attribute concepts. As also described in chapter 5, this concept was chosen as students seemed to experience problems in identifying entity types and distinguishing entities from attributes, and hence, it was expected that using the game as a medium in teaching this knowledge was likely to prove helpful. A computer program named MoRes was also developed in order to acquire the initial values for the model. Once the model was initialised, the specific version of the game that was likely to suit a learner's trait characteristics would be selected. When the learner finished playing the game, MoRes would ask him/her to report the values of two motivational states (attention and relevance) and MoRes would infer the values of the other motivational states as they chronologically appeared in the preliminary model including his/her motivation at the end of the game. (further details regarding MoRes can be found in section 5.3.2).

In addition to these central instruments, some other materials were needed to satisfy the demands of ethical considerations, to prepare the participants to take part in the study and to gather the required data from the participants. In total, seven documents were developed to use in the study. These documents are: a plain language statement, a consent form, an instruction sheet for the study and copies of the research tools (e.g. pre-questionnaire, post-questionnaire, the snapshots of some scenes in the game and a retrospective self-report). The plain language statement contains details about our research study whereas the consent form is a form that will be signed by the participants who agreed to take part; these two documents were developed to satisfy the demands of ethical considerations. The instruction sheet for the study provides the details of how to complete the study; this can be regarded as a participant preparation document for participants taking part in the study. The other four documents were used for gathering the required data from the participants. The pre-questionnaire is a tool used for gaining background information from the participants on database modelling and computer games whereas the post-questionnaire is an instrument aimed at obtaining the overall value of the participants' motivation when finishing the game. We considered motivation as a dynamic system in which its value changes over time and hence, to gain a better understanding of its dynamic view, the retrospective self-report[2] was developed based on a five-point Likert rating scale (Very Low, Low, Not Applicable, High and Very High) to acquire the motivational data of the participant while playing the game.

[2] There is a large amount of existing literature review on the use of self-report in measuring attitude (e.g. Weiner, 1984; Henerson et al., 1987).

Eight snapshots[3] that capture a single scene or multiple scenes of the game were also created to represent the chronological-key events and they were also employed to help extract the retrospective report from the participants. A webcam was planned to be used in the study to obtain qualitative data (e.g. facial expressions and gestures) of the participant when playing the game. The data generated by the webcam was used to support data from the questionnaires and self-report.

## 6.3 Participants

In order to obtain participants for this study, we contacted students in the Department of Computing Science at the University of Glasgow and asked for volunteers. This group of students was considered to be our potential user group as the domain knowledge of game prototype involves some concepts of databases, which is one of several computing subjects. It was considered that in order to see whether the game was helpful and useful for learning, it seemed reasonable to test the game with the students who seem to benefit from it most. The choice of the university is mainly pragmatic. The students were informed that their participation would help us in our research in bringing technology into education to improve the learning process, and that they would have to interact with the program – MoRes and subsequently, play the game – Alex's Adventure which aims at teaching some concepts about databases.

As a result of our request, 27 computing students – 10 postgraduate students and 17 undergraduate students with some background in databases volunteered to participate in our study. The study was designed to be on a one-to-one basis to allow careful observation of the participants as they interacted with the game. In some cases, a semi-structured interview was arranged to get more precise data.

[3] The first snapshot captures the beginning scenes of the game ('Opening & Invitation' scenes). The second snapshot captures the scene involving a non-academic task ('In the Forest' scene). The third snapshot captures the scene that introduces the other two main characters – Dr de Ville and Mary, his assistant ('Meet Dr de Ville' scene). The fourth snapshot captures the scene in which the first academic-related task is presented ('First Task' scene). The fifth snapshot captures the scene where the explanation about the first task is given by the character – Mushyman ('Meet Mushyman #1 scene). The sixth snapshot captures the scene in which the second academic-related task is shown ('Second Task' scene). The seventh snapshot captures the scene where the explanation about the second task is also given by Mushyman ('Meet Mushyman #2 scene). The eighth snapshot captures the ending scenes of the game ('Back to Emma' scene).

# 6.4 Methodology of Study

## 6.4.1 The Pilot Study

Before conducting the main study, all materials were tested for their utility with two students from Glasgow University. The entire process involved in running the main study was also piloted. As a result of the test, the use of the webcam was found to be intrusive for one student. Hence, we decided that when conducting the main study, each participant would be asked whether he/she felt comfortable with the use of a webcam. If he/she did not feel comfortable, then, the webcam would not to be used.

## 6.4.2 The Main Study

On arrival at the room where the study was to be performed, the participant was given three documents: the plain language statement, the consent form and the instruction sheet for the study (these are reproduced in Appendix B). After reading these documents and signing the consent form, the participant was asked to fill in the pre-questionnaire. The questionnaire can also be found in Appendix B. Once this questionnaire was filled in, the interaction with MoRes and Alex's Adventure started.

Participants' interaction with the prototype lasted for a varying amount of time, ranging from 30 minutes to 45 minutes, and was recorded using a webcam. At the end of the interaction, the participant was asked to fill in the post-questionnaire regarding his/her motivational characteristics and opinions towards the game. The questionnaire can be found in Appendix B. After completion of the questionnaire, two further documents (which can also be found in Appendix B) were given out: one consisted of a selection of snapshots for representative scenes in Alex's Adventure and the other one a retrospective self-report contained questions on the motivational values of the participant which are related to the snapshots. In total, each participant took about one hour to one hour and a half, and we were able to gather a considerable amount of data.

Additionally, observational notes were recorded by the observer during the interaction and during a semi-structured interview[4] with some participants after the session.

[4] The semi-structured interviewed conducted in the main study was done in a less formal fashion (that is, it was regarded as an informal conversation between the observer and the participants). The purpose of the interview, mainly, was to clarify the data obtained from the participants as there were cases where the data reported by the participants/the comments made by them were not clear.

## 6.5 Methodology of the Data Analysis

Apart from the methodology of study, we also described the methodology used for the data analysis. Two choices of common approach used in modelling were considered: quantitative approach and qualitative approach. However, as mentioned in chapter 1, the qualitative approach was chosen to be used when modelling motivation. One may question what made us decide to do qualitative analysis rather than quantitative analysis since the latter, to computer scientists, may seem to be a more straightforward approach. In order to answer this question adequately, we set the following sub-questions:

1. Which approach should be employed in doing data analysis – is the analysis primarily qualitative or quantitative?

2. Which strategy should be used in doing qualitative data analysis?

3. How many cases should be selected? And what are the criteria used in selecting each case? clear
4. Which displays should be used in doing case study analysis?

**1. Which approach should be employed in doing data analysis – is the analysis primarily qualitative or quantitative?**

To validate our preliminary model, we decided to analyse the data using a qualitative analysis approach; moreover, the overall data analysis was heavily influenced by Miles & Huberman (1994). The motivation for applying this approach stems from our consideration of motivation as a dynamic and complex system which is difficult to inspect. The qualitative approach, as suggested by Miles & Huberman, has strong potential for revealing complexity since qualitative data can provide thick and vivid descriptions which have a powerful impact on the reader. Furthermore, the qualitative analysis focuses more on the process and meaning. Hence, it can be used to provide a better cognitive account of what is going on when learners are motivated and to suggest the causality of motivation as it actually plays out in our game-based learning context. However, the approach still has some disadvantages. For example, it is hard to extend the findings to a wider population unlike the quantitative analysis approach. The findings from the quantitative analysis can potentially be generalised to a larger population, but the limitation of the approach is that it cannot provide rich descriptions compared to those obtained through using the qualitative approach. Also, the quantitative analysis tends to remove rare occurrences to ensure that reliable results were obtained from certain statistical tests and this leads to a loss in data richness.

From our point of view, there are methodological advantages in applying the qualitative rather than quantitative approach since the data from each single participant are rich and, therefore, a deep analysis can be done for each participant. Moreover, the qualitative analysis enables us to explore the phenomena of one's motivation in great detail resulting in descriptions which can be used as a basis for further investigations using statistical methods such as hypotheses testing and so on. As noted by Schmied (1993), a stage of qualitative research is often a precursor for quantitative analysis.

## 2. Which strategy should be used in doing qualitative data analysis?

A case study analysis was chosen as a specific method for analysing the data. The method is known as a way of investigating an empirical topic by studying in depth a single case example of the phenomena – the case can be an individual person, an event or an institution. As suggested by Yin (1994, p. 6-9), the method is suitable for answering "how" and "why" research questions because such questions deal with operational links that need to be traced over time, rather than frequencies or incidences. It is also a preferred strategy for examining contemporary events, especially when the relevant behaviours cannot be manipulated. However, one may regard his suggestion as over criticism.

As stated at the beginning of the thesis, our research questions focus on determining a motivational structure for learners during their interaction with an educational game and the way it might change during the interaction. In other words, the questions are more likely to be a how-question type: how learners are motivated through the educational game and how their motivation changes during interaction with the game. Furthermore, we considered that in order to determine the motivational structure across learners, it is necessary to understand the structure of motivation within an individual learner first. Hence, we decided to apply the case study analysis to our research since it was considered to be the most suitable and viable analysis strategy in this research context.

**3. How many cases should be selected? And, what are the criteria used in selecting each case?**

Before deciding the number of cases we should analyse, it was considered that the general principles of the analysis should be clearly specified first. In the real world context when a group of students are asked to interact with a computer-based instruction, it is likely that some of them are motivated by the instruction whereas some of them feel less or not at all motivated. And if the instruction is developed on a game-based basis, there seems to be two groups of people who are motivated – those who are motivated to play and those who are motivated to learn. Since a model is seen as a simplified version of a real-world situation, the general principles of our analysis are based on what we have described so far. That is, in order to build a model of motivation, we needed to find both students who are motivated in our instructional context and those who feel less or not at all motivated, then, examine and compare their motivation model; also, we need to distinguish between those who are motivated by game playing and those who are motivated by learning.

Based on these general principles, we ran the study with 27 voluntary participants. We then looked through all participant data and we noticed that the data could be categorised into two groups: data from participants who reported to be motivated[5] by the game and data from participants who reported not to be motivated[6] by the game. There were 24 participants who reported to feeling motivated whereas only 3 participants reported not feeling motivated. These 3 participants were asked to play the game again, but this time they were given the version that was predicted to be an improvement of the previous game (the adjusted version as described in chapter 5). One of them reported to be motivated by the second version of the game while the other two participants remained unmotivated. We considered that these 3 participants were special since the majority of the participants were motivated from the first-time play and even after playing the adjusted version, some of them were still not motivated. Thus, we decided to analyse these 3 participants to investigate their motivation further.

We also considered it was important to investigate the motivational structure of the participants who reported to be motivated by the game from the first-time play since

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[5] The participants who are motivated by the game refer to those who reported to be motivated to both learn and play in the game environment.

[6] The participants who are not motivated by the game refer to those who reported to be motivated to play, but not to learn in the game environment and those who reported not to be motivated to both learn and play.

they can be regarded as normal cases, and hence, we decided to pick 3 participants out of 24 for the case analysis. These participants were chosen since they were given different versions of the game based on their trait characteristics and also, there was a consistency among the data reported by these participants through different sources. As for the data from the rest of the participants, they were not included as it was considered that practically, analysing each single case was a time-consuming task and within a limited timescale we could manage to analyse a small number of cases. Thus, the notion of selecting cases seemed to be reasonable and we considered those 3 participants as representatives of the normal cases.

We expect that an in-depth analysis of the data obtained from these 6 participants could shed the light on the relationship between trait characteristics of learners and features of an ILE according to the preliminary model shown in chapter 4.

In summary, 6 cases were chosen for the case study analysis – 3 motivated cases and another 3 cases who were not motivated from the first time of playing.

## 6.6 Summary

As mentioned earlier, the main goal of the study was to get the motivational data of the learners during their interaction with the game which will be used for validating our preliminary causal model. Hence, two studies were conducted to achieve this goal: the pilot study and the main study. The pilot study was carried out to test all materials and the procedure used in the main study. The process for conducting the main study was described. In addition, the method for data analysis was discussed. In the next chapter, issues relating to the data (e.g. what data was gathered? what data was used?), the initial analytic categories (how the analysis of an individual case was done) and the use of various representations to analyse data of a single case will be discussed. Also, the analysis of two case studies will be presented as examples that illustrate these issues.

# Chapter 7

# Case Study Analysis

## 7.1 Introduction

As described in chapter 6, we chose to validate our preliminary causal model of motivation using qualitative analysis approach as it was considered to be capable of revealing the complex nature of learners' motivation. In particular, we are interested in determining a motivational structure for learners in a game-based learning environment and the way it may change during interaction with the learning environment, so we can seek to manipulate that in a sound ethical and pedagogical manner. It was considered that to be able to determine the motivational structure across learners, it seems that we need to understand the motivational structure of an individual learner first and thus, case study analysis was chosen as a specific method for analysing the motivational data of students who participate in our main study.

In this research we decided to study 6 cases in detail: 3 motivated cases (participants who reported to be motivated by our game prototype) and 3 non-motivated cases (participants who reported not to be motivated by the game). Those 3 motivated cases were selected as there was a consistency among the data reported by them through different sources and also, they were assigned by a computer program – MoRes – to play different versions of the game based on their trait characteristics. As for the other 3 non-motivated cases, they are the participants who were considered to be the special cases which need to be investigated further about their motivational structure since they reported not to be motivated to learn with the game and hence, they were asked to play another version of the game that were predicted to be an improvement of the previous version. However, only 2 cases are presented in this chapter – one is the motivated case (case study 1: case E02) and another one is the non-motivated case (case study 6: case E09). These two cases were chosen as they were considered to be representative of the motivated cases and the non-motivated cases, respectively. The analysis of the other cases (case study 2 – case study 5) can be found in Appendix C – Appendix F.

In the following section we discuss issues relating to our data, specifically, the issue of the data gathered from the field study and the data used in doing case study analysis; we also describe the initial analytic categories applied to each single case in the aspects of how the study of a single case was carried out and the representations used in the study. Then, we illustrate these issues through the analysis of case study 1 and 6 in section 7.3 and 7.4, respectively before concluding with a chapter summary.

## 7.2 Preliminary Analytic Issues

### 7.2.1 Data Gathering and Data Usage for Analysis

When conducting the main study, several kinds of data were collected. The data gathered included 1) background information in databases and in computer games obtained through the use of pre-questionnaire 2) the participant's preferred learning style obtained through the electronic questionnaire implemented in MoRes 3) the participant's facial expressions and gestures obtained through the use of webcam and observational notes 4) the motivational data at the end of the interaction obtained through the use of post-questionnaire and observational notes 5) the motivational data during interaction with the game obtained through the use of retrospective self-report and observational notes.

Most data were used when doing case study analysis. However, the data from the webcam was planned to be used as supporting evidence to infer the motivation of a single case during interaction with the game. The evidence would be used for the purpose of reconciliation in case there were some discrepancies between the data reported by the participant and the data observed during the field study (e.g. there might be a case in which the participant reported to be motivated at the end of the game, but when looking at the data from other recorded sources this was likely not to be the case and thus, we might need to refer to the data obtained from webcam in order to remove these discrepancies).

### 7.2.2 Initial Analytic Categories and Analytic Representations

The study of all cases was planned to be done in a similar fashion. For each single case, we start with the background of the case before moving on to describe his/her motivation. After that, we explain the motivation of the case in the aspect of a causal mechanism between different features of the game ILE and different motivational states which were considered to constitute a learner's motivation. Then, we conclude with the summary of the case.

In order to perform the case study analysis, several representations are employed as mentioned earlier. These representations can be categorised into two types: representations for describing motivation of a single case and representations for supporting explanations about a causal mechanism between the features of the game and motivation. The detail of each type of representation is explained below. An illustration of the use of these representations is shown in the analysis of case study 1 and case study 6 (sections 7.3 and 7.4, respectively).

#### 7.2.2.1 Representations for Describing Motivation

These representations will be used for describing the motivation of each case study in the context of an educational game. Four representations will be employed for the purpose of drawing descriptive conclusions.

- **Checklist Matrix on Facial Expressions and Gestures**

  A checklist matrix is a table which can be used for describing data from two sources: webcam and observational notes. The data can be described in two aspects: facial expressions and gestures. As mentioned earlier in section 7.2.1, the data from webcam would be used as supporting evidence in case there were some discrepancies between the data reported by the participant and the data observed during the field study; thus, the checklist matrix will be presented separately from the analysis of each case and will appear in Appendix G.
- **Event Listing of Motivational State**

  An event listing is a format which can be used for presenting the occurrences of a participant's motivational states during interaction with the game. The data that appear in this representation is based on the self-report in which each participant was asked to rate his/her feelings that occurred at different stages of the game. Eight snapshots that capture a single scene or multiple scenes of chronological-key events are used to represent these stages. In addition, a description for the event listing will be provided in order to describe the data shown in the format; the observational notes were also planned to be used when creating the description as we considered that by reconciling the data from two different sources (one is from an individual participant (self-report) and another one is from a researcher (observational notes)) would increase the reliability of motivational inferences made in the description. As discussed by Reid (2006), attitudes can be regarded as a latent construct which is not open to direct measurement and thus, all attitudes must be inferred. Thus, in describing the participants' observed behaviours, inference was made through the use of terms (e.g. looked, seemed).

- **Plot of Motivational State**

  A plot of motivational state is a display of two variables. One variable is time (x-axis) which is represented by snapshots that capture different scenes of the game. Another variable is a particular motivational state of a learner. The data that appears in the plot is based on the self-report in which each participant was asked to rate his/her feelings that occurred at different stages of the game. According to the preliminary model, there are two types of motivational state. The first type is the motivational state which was considered to be affected immediately by the features of the game (attention and relevance); thus, the value of attention and of relevance were measured against the relevant game features as appeared in the model (attention – imagery, attention – feedback, attention – cognitive tool, relevance – goal: support learning, relevance – goal: provide fun, relevance – content). The second type is the motivational state which was considered to be affected by either attention or relevance, or both (cognitive curiosity, effort and confidence); hence, the value of these motivational states was not measured against any feature. The plot is used for tracking the values of a participant's motivational state during a trial as it was considered to be useful in that it provides us with a dynamic view of a particular motivational state – how it changed over time. Three plots will be created. The first two plots are the plot of attention and the plot of relevance assessed against different features of the game as explained earlier. The last plot is the plot of cognitive curiosity, effort and confidence.

- **Effects Matrix of ILE Features**

  It was considered that we needed to examine outcomes of assigning an individual learner to the game that is likely to be motivating to him/her as this is an important part of answering our research question – how learners are motivated through the game ILE. By examining the outcomes, we will be able to validate our preliminary model in the aspect of how the game impacts on the motivational structure of an individual learner. These outcomes refer to learners' motivational states which were considered to be affected by different features of the game. We considered that the outcomes can be of several types and can be sorted according to their directness. Three kinds of outcomes were considered to happen in our context. The first kind of outcomes can be viewed as immediate outcomes which refer to the motivational states that were immediately affected by the game features; this kind of outcomes can be termed ‘direct effects’. The second kind of outcomes is outcomes that go beyond the immediate outcomes; these outcomes refer to the motivational states which were affected after and can be termed ‘meta effects’. The third kind of outcomes is outcomes that were far away from our original intention and can be termed ‘side effects’.

A table of effects matrix will be created based on the data retrieved from a single participant using post-questionnaire, self-report, observational notes and semi-structured interview. The table describes the effects of the game features on the motivational states of the participant. The table displays five ILE features which constitute the game and three kinds of effects considered to be caused by these features. The data obtained from the above sources were reconciled, interpreted and presented in a narrative form as it was considered to be a more flexible form that allowed for a wide range of possible data and could provide a rich description.

#### 7.2.2.2 Representations for Explaining Motivation

Since we are interested not only in describing the occurrence of motivation but also predicting it, we have to go far beyond description; we have to be able to explain: how motivation occurs and what causes it? Hence, another three representations will be developed to support explanations about motivation of each single case. These representations are described below.

- **Explanatory Effects Matrix**

  As explained earlier, we need to be able to explain a phenomenon of one’s motivation in order to be able to predict it. Thus, an explanatory effects matrix is employed as a first step in an attempt at explaining motivation. As stated by Miles & Huberman (1994),

  > “The [explanatory effects] matrix helps us understand things temporally, and we get a first feel for the causal mechanisms that may be involved.” (p.148).

According to the preliminary model shown in chapter 4, the model shows the relationships among three categories of variable: trait characteristics, ILE features and state characteristic. As explained in the same chapter (see section 4.2.3), it was considered, based on relevant literature, that the trait characteristics of a learner can influence the use of the features in a game-based learning environment directly, either increasing or decreasing the use of them; thus, the features of the game should be able to adapt themselves according to the learner's trait in order to suit their learning preferences; and, by designing a game-based ILE that contains such adaptive capabilities can potentially have a positive impact on the learner's motivational states. The explanatory effects matrix is used in our context to display the overall picture of the relationships among these variables in a form of a table.

The matrix will be created based on the data retrieved from a single participant using a post-questionnaire and a self-report, and the data from the semi-structured interview. The matrix consists of five columns. The first column presents the trait characteristics of the participant. The second and the third column demonstrate the design of the game features which is influenced by the participant's trait characteristics. The other two columns show the outcomes of designing the game according to the participant's traits. It was considered that the outcomes could be separated into two types: the short-run effects and the longer-run consequences. The short-run effects refer to the motivational states of the participants during interaction with the game. These motivational states were considered to change over time – once the particular state occurred, it had a specific value which lasted for a while before changing again. In other words, the short-run effects can be seen as the process perspective of motivational states before settling down similar to that of flow (Pearce et al., 2005). We also considered that the short-run effects can be divided into two types according to the directness: direct effects and meta effects, as explained earlier. On the contrary, the longer-run consequences refer to the motivational states of the participant after interaction with the game was finished. These motivational states can be seen as the overall-state perspective similar to that of flow (Pearce et al., 2005); these motivational states will be called 'overall state' throughout the remainder of the thesis. The overall state can also be divided into two categories: initial state (the state that was directly affected by the game features) and consecutive state (the state that was affected after the initial state).

- **Case Dynamics Matrix**

Even though the explanatory effects matrix can provide us with a notion of cause and effects in the context of an educational game, it is not able to provide us with a dynamic view of these causes and effects; in other words, the matrix cannot tell us how and in what way the game features relate to the motivational states and thus, it is difficult to see the links between the features and the motivational states.

A case dynamics matrix, on the other hand, is a representation that is likely to be able to show this dynamic aspect as put by Miles & Huberman (1994),

> "A case dynamics matrix displays a set of forces for change and traces the consequential processes and outcomes." (p.40).

Hence, this matrix is employed in order to display how the features of the game ILE may cause changes in the values of the motivational states of a participant. The matrix will be developed based on the eight snapshots of key-events in the game. However, it was considered that these snapshots contain related events in which some of them can be grouped together. Hence, we categorised the snapshots and divided them into four stages: 'The Prelude' which involves snapshot 1 – snapshot 3, 'The First Task' which involves snapshot 4 – snapshot 5, 'The Second Task' which involves snapshot 6 – snapshot 7 and 'The Finale' which involves snapshot 8.

Based on this categorisation, four case dynamics matrices were created. The first matrix consists of four columns. The first column shows which features were present or absent from the game. The second column displays the values of a participant's motivational states during the first stage: 'The Prelude' whereas the third column presents the issues related to motivational states. The last column provides the details of what could be done to the features of the game in order to sustain or increase the value of the motivational states; this column can be seen as forces that cause changes in the motivational states of the participant. The other three matrices (created for the 'First Task' stage, the 'Second Task' stage and the 'Finale' stage) were developed in a similar fashion except that an extra column will be added. This column presents the details of the anticipated changes in the features of the game in the light of an attempt to maintain or raise the value of the motivational states.

- **Revised Causal Model**

  Case dynamics matrices help us understand the dynamic aspect of a learner's motivation, specifically how the features of the game ILE caused changes in the values of the motivational states. However, it is difficult to see from the matrices the variables involved in the context and the relationships among them.

  Thus, we considered bringing together these variables and their relationships, and presenting them in a coherent picture by making use of a causal network. As stated by Miles & Huberman (1994),

  > "A causal network is a display of the most important independent and dependent variables in a field study (shown in boxes) and of the relationships among them (shown by arrows). The plot of these relationships is directional rather than solely correlational. It is assumed that some factors exert an influence on others: X brings Y into being or makes Y larger or smaller. A causal network, to be useful, must have associated analytic text describing the meaning of the connections among factors." (p.153).

  Based on their statement, the causal network seems to be the viable representation for demonstrating and describing the motivation of a learner in a way that is clear and easy to understand.

  The revised version of the preliminary model of motivation was produced for each single participant and it was in a form of a network, showing the independent and dependent variables, and the relationships among the variables. The variables are represented by boxes whereas the relationships are represented by arrows. The network is associated with text to describe the meaning of the relationships among the variables.

# 7.3 Case Study 1: Case E02

## 7.3.1 Background of Case Study 1

The participant is a male gender whose age is between 20 – 25 years old. He is an international student and he was doing his master degree in computing science. He has a reasonably good knowledge in database modelling. Furthermore, he likes playing computer games and has played several kinds of game e.g. strategy game, shooting game, etc. At the start of the session with our computer program – MoRes, the participant was asked to provide the data about some of his trait characteristics in a learning environment. These characteristics are shown in Table 7.1.

Based on his trait characteristics, MoRes assigned him to play Alex's Adventures 2.0[1].

| Control | Challenge | Independence | Fantasy |
|---|---|---|---|
| High | High | High | High |

Table 7.1: Trait characteristics of case study 1

## 7.3.2 Representations for Describing the Motivation of Case Study 1

### 7.3.2.1 Event Listing of Motivational State

A table of event listing was created as shown in Table 7.2 and the table was built based on the data reported through the use of a retrospective self-report.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Attention | Imagery | VH | VH | H | VH | VH | H | H | H |
| | Feedback | AS | AS | AS | H | AS | L | AS | AS |
| | Cognitive Tool | AS | AS | AS | AS | VH | AS | H | AS |
| Relevance | Content | VL | VH | N/A | L | VH | H | H | H |
| | Goal: Support Learning | VL | N/A | N/A | L | VH | H | VH | VH |
| | Goal: Provide Fun | VH | H | VH | H | VH | H | VH | VH |
| Cognitive Curiosity | | L | VH | VH | H | H | L | N/A | VH |
| Effort | | H | VH | L | N/A | VH | N/A | VH | H |
| Confidence | | H | VH | VH | VH | H | VH | H | H |

Legend:
VL = Very Low
L = Low
N/A = Not Applicable
H = High
VH = Very High
AS = Absent feature from the scene

Table 7.2: Event listing of motivational state of case study 1

Based on the data shown in the table and our observational notes, the participant seemed to pay attention to the beginning scenes (stared at the 'Opening' scene for a while; read an introduction to all characters in the 'Invitation' scene carefully) and looked curious and ready to start playing the game (clicked the button 'Play Game' immediately; used one hand to grab a mouse and another hand to press arrow keys). When the participant was presented with the 'In the Forest' scene where he met a new character – Blockhead, it seemed that his attention was attracted by a conversation with

[1] The specifications of Alex's Adventure 2.0 were described in chapter 5 (section 5.3.1.4).

this character. And when he was asked to do an activity – finding all mushrooms in the forest – in order to progress to the next scene, he looked curious and made an effort in finishing it (looked over the screen for the mushrooms **(:G1)**). After he finished doing the activity and saw the scene was changing, he looked satisfied **(:F1)**. When the participant was presented with the following scene, it looked like his attention was drawn by the appearance of and the conversation with the other two characters – Dr de Ville and Mary. Also, he looked interested in having a conversation with these two characters (seemed to think along **(:G2)** and clicked the button to close the conversation dialogs quicker as time passing **(:G3)**). However, it looked as if he felt slightly unsure at first when he was not able to control the main character – Alex, but seemed to relieve when seeing the other character (Dr de Ville) walking towards Alex instead. In the subsequent scene – the 'First Task' scene, the participant was likely to be attracted by objects and dialog boxes describing the scenario of the task and how to do it. He seemed to have a high concentration when doing the task (checked the information kept in each chest before choosing which one he was going to move **(:G4)**). After finishing the task with the highest score, he looked satisfied **(:F1)**. The participant seemed to attract to the new character – Mushyman – when it first appeared in the 'Meet Mushyman #1' scene and he seemed to concentrate on the explanation about the knowledge embedded in the task given by this character (**(:G2)**; move a mouse along the explanation text **(:G5)**). Furthermore, it looked as if he found the relevance between the task and the knowledge aiming to be delivered as he nodded his head after the explanation was finished **(:G6)**. However, in the following two scenes (the 'Second Task' scene and the 'Meet Mushyman #2' scene) in which the participant was asked to do the second task and was presented with the explanation about the task once again, his reactions were similar to those when he was doing the first task and met Mushyman for the first time except that the degree of his feelings was likely to decrease (looked relax **(:F2)**). However, the participant seemed to be attentive to the game once again in the last scene in which the main character was brought back to the place where the whole story began. He also looked curious about what was going to happen in this scene (moved the main character to Emma's house without bothering to explore the scene **(:G7)**). When the game was finished, the participant seemed to feel happy (**(:F1); (:F2)**).

### 7.3.2.2 Plot of Motivational State

Three plots of motivational state were developed as described in section 7.2.2.1. The first plot is a plot of attention which was measured against three features of the game:

imagery, feedback and cognitive tool. The second plot is a plot of relevance which was measured against two features: instructional goals (support learning and provide fun) and content. The third plot is a plot of three motivational states: cognitive curiosity, effort and confidence, which, according to the preliminary model, were considered to be affected by either attention or relevance, or both.

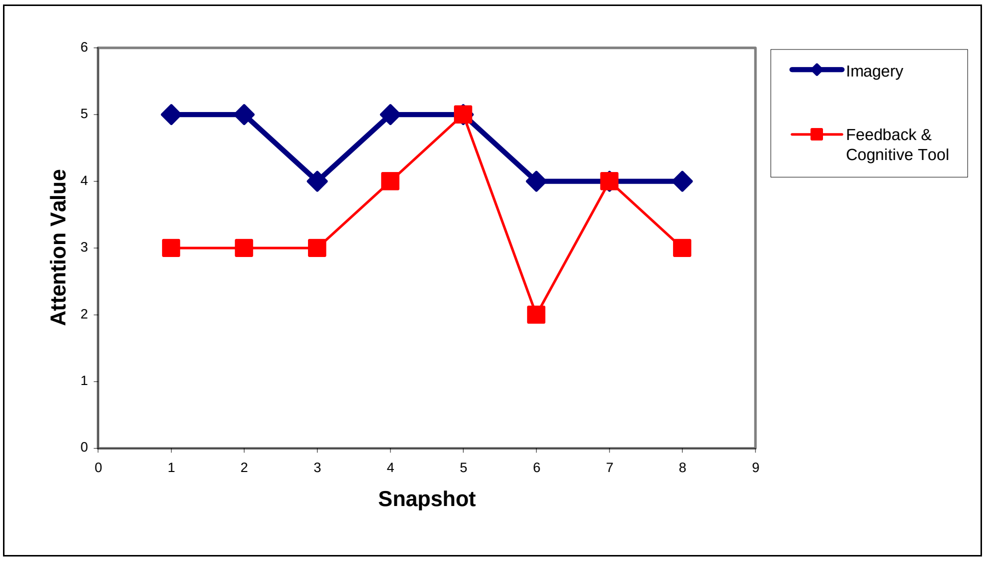


Figure 7.1: Attention value towards three features of the game during interaction

Figure 7.1 shows the values of the participant's attention towards three features: imagery, feedback and cognitive tool during the session with the game. One may question why only one graph is used to present the level of attention paid to two different features: feedback and cognitive tool – why not separate this graph into two (one showing the participant's attention paid to feedback and another one showing his attention paid to cognitive tool similar to what was done to the feature: imagery). The reason behind this is that feedback and cognitive tool did not appear at every stage of the game unlike imagery – that is, feedback was only presented when Alex did the tasks in the game (snapshots 4 and 6) whereas cognitive tool was presented when Alex finished doing each task (snapshots 5 and 7). Because of this, it was considered that using one graph did not make any difference from using two graphs as both features were presented at the different stages. This consideration was also applied to the analysis of the other cases. According to the figure, it seems that the participant was highly attracted to the imagery used in the game (Attention Value = 4 and Attention Value = 5). The participant reported to pay very high attention at the beginning of the game. Then, his attention dropped slightly when a less colourful scene was presented (snapshot 3 – 'Meet Dr de Ville' scene ). However, he reported to feel very highly attracted when he was given the first task and the explanation about the knowledge embedded in the task. After that, his attention decreased slightly once again and remained high until the end of the game. It was considered that the drop in the participant's attention in the last three snapshots might be because some repetitive scenes were presented and even though a new scene was introduced (snapshot 6), there was still a similarity compared to the earlier scene (snapshot 4). Also, as can be seen from Figure 7.1, the participant reported to pay high attention to the feedback given when he was doing the first task, but, a low attention was paid to this feature in the second task. The sharp drop in his attention might be because he was again given the same style of feedback. As for the feature: cognitive tool, the participant was very highly attracted when the tool first appeared; however, when it was presented for the second time, the attention paid to this feature seemed to slightly decrease.

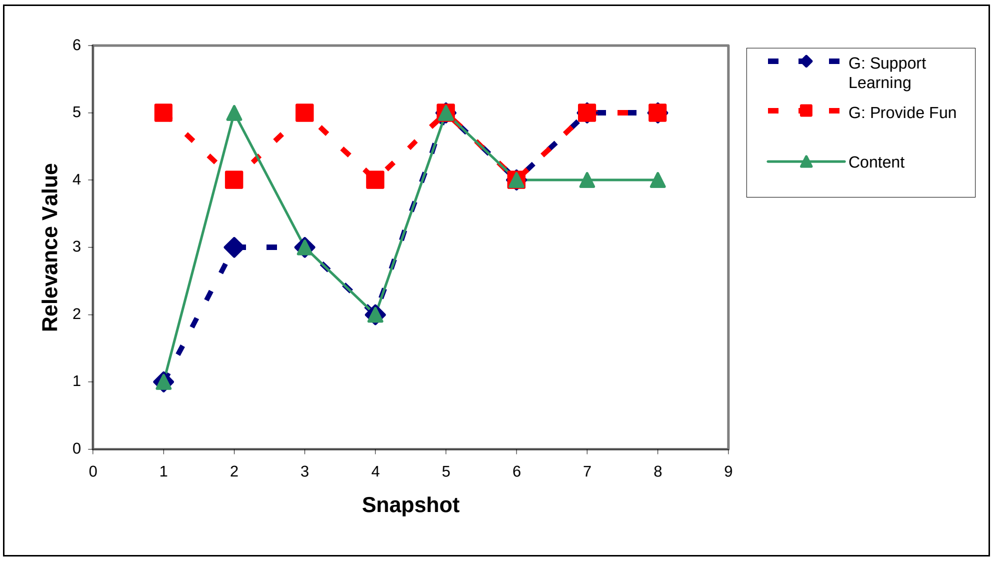


Figure 7.2: Relevance value towards two features of the game during interaction

Figure 7.2 shows the participant's feelings of relevance towards two features of the game: instructional goals (support learning and provide fun) and content during interaction with the game. According to the figure, it was considered that the participant might not have the goal in learning some concepts in database modelling from the game in the first place as his feelings of relevance between the instructional goal in supporting learning and his goal in learning were reported to be very low in the first snapshot. Furthermore, when he proceeded to the following scene (snapshot 2), he was not able to report whether he wondered how the activity given in this scene (finding all the mushrooms) related to learning databases and when he had the conversation with the character – Dr de Ville who offered him a job to do in order to earn money for buying the medicine (snapshot 3), he was also not able to report whether he had any suspicion towards the tasks that they might involve with learning databases. In the fourth snapshot where the participant was given the first task, he reported not to be aware of the fact that the task encapsulated knowledge in database modelling (Relevance Value = 2). Based on his report, it seems that the participant did not have a feeling to learn from the beginning of the game up to this point. However, the participant's feelings of relevance were reported to be very high when the character – Mushyman first appeared to explain the knowledge embedded in the task. The feelings were reported to slightly drop to a high level when he was given the second task but it was reported to increase to a very high level once again when Mushyman showed up for the second time; after that the feelings remained stable at this level until the end of the game. Based on the participant's report, it is likely that his goal in learning was developed later in the game (when the knowledge embedded in the tasks was made clear to him). On the contrary, the participant seemed to have the goal in having fun with the game from the beginning and this goal was likely to be satisfied throughout the game session as the values of his feelings of relevance between the instructional goal in providing fun and his goal in having fun fall into the high-value area (Relevance Value = 4 and Relevance Value = 5) from the start to the end of the interaction. In addition, the participant reported that he felt a high coherency in the storyline and the story could fulfill his goal in having fun; the story was also able to influence his feeling to learn from the game which did not seem to exist at the beginning. According to the participant's report, it seems that to some extent, the relationship between the content of the game and his feelings of relevance exist and if the content is well-designed, it can fulfill the goal of the participant (to have fun when playing the game) or even enable the occurrence of the new-desired goal (to learn from playing the game).

Figure 7.3 shows the values of three motivational states (cognitive curiosity, effort and confidence) of the participant during the session with the game. According to the figure, the participant reported to have a very low level of cognitive curiosity at the start of the game; however, his curiosity was reported to be driven to a high level afterwards (Cognitive Curiosity Value = 4 and Cognitive Curiosity Value = 5) and remained at this level until he finished doing the first task and was given the explanation about the knowledge embedded in the task (snapshot 2 – snapshot 5). When the participant was given the second task (snapshot 6), his curiosity was reported to drop to a low level and when Mushyman appeared for the second time in order to explain about the knowledge in the second task (snapshot 7), he was not able to report the level of his curiosity. The fall in the curiosity level in these later scenes might be because of the similarity nature of both tasks, and of the explanations given after the tasks. Nevertheless, his curiosity was reported to increase to a very high level once again in the last scene (the participant might wonder what was going to happen next – was it going to be the end of the story? how the story would end? and so on).

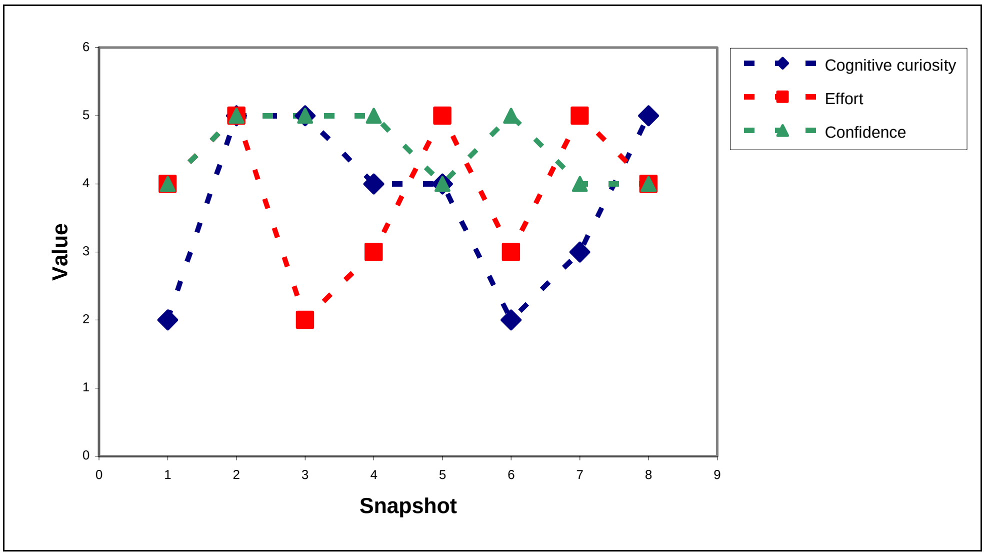


Figure 7.3: The value of cognitive curiosity, of effort and of confidence during interaction

As for effort, the graph is rather straightforward. The participant reported to use a high effort in the scenes that required actions/critical thinking from the player (snapshots 1, 2, 5, 7 and 8). However, there is a point in the graph (snapshot 3) where the participant reported to use a low effort. The snapshot captures the scene of Dr de Ville's library and as previously explained, this scene was rather created to make the story flow and there was no activity involved in the scene (the main character stood still, waiting for the other characters to come and started talking, and hence, the participant might feel that he did not use any effort in this scene). Also, there are two points in the graph in which the participant was not able to report the level of effort used in playing the game; these two points are the points where the first and the second task were given (snapshots 4 and 6, respectively). The reason for which the participant was not able to report the level of effort used might be because he did both tasks very well and could complete them without making any mistake and thus, he might feel that he did not use much effort in solving the problems of the game.

As for confidence, the graph fluctuates between a high and a very high level. The participant reported to feel highly confident at the beginning of the game and his confidence was increasing as progressing through the game. However, his confidence dropped slightly to the level of high in the scenes where the explanations about the embedded knowledge in the tasks were given. Based on his report, it is likely that the confidence of the participant was sustained throughout the game interaction.

### 7.3.2.3 Effects Matrix of ILE Features

A table of effects matrix (Table 7.3) was created according to the description in section 7.2.2.1. The table describes the effects of the game features on the motivational states of the participant in the aspect of how ILE features cause three different kinds of effects. The description of the table (below) was created based on existing literature (section 4.2.3) and evidences (data from post-questionnaire, self-report, observational notes and semi-structured interview).

| **ILE Features** | **Direct Effects** | | **Meta Effects** | | **Side Effects** |
|---|---|---|---|---|---|
| | + | - | + | - | + |
| Imagery | Attracted the attention of the participant instantly | Slightly bored to see repetitive scenes | Curious about what the next scene would be | Less curious in the scenes which contain some similarities compared to the earlier scenes | |
| Feedback | Drew the participant's attention regarding his performance when doing the first task in the game | Less attracted to the same feedback given during the second task (short praises) | Interested in receiving some feedback when doing the first task | A lower interest to see the same feedback (short praises) in both tasks | |
| Cognitive Tool | Caught the attention of the participant by an immediate appearance and an explanation | Felt less attentive to the explanation in the second task | Curious about how the first task was relevant to databases | Not able to report about the curiosity when receiving the explanation in the second task | |
| Content | Interested in the storyline of the game | Could not clearly see how the first task was relevant to databases | Wanted to find out how the story would end; curious about how the first task was relevant to databases | | Widen the participant's view about learning databases in a new environment other than a classroom setting |
| Instructional goals | Wanted to have fun and the game could fulfil the feelings | | A good idea to learn databases in the new learning environment | | |

Sources: Post-questionnaire, retrospective self-report, observational notes and semi-structured interview

Table 7.3: Effects matrix of ILE features of case study 1

It seems that the participant was attracted to the imagery used in the game and it also made him felt curious about the following scenes; however, a lower level of attention and of curiosity were reported when the repetitive scenes were presented. When the participant was given the first task, he reported to pay attention to the feedback given during the task as he was curious about his performance, but in the second task this did not seem to be the case; the participant reported that he always received short praises (e.g. 'Very Good', 'Excellent, etc.) similar to when he did the first task. When the participant finished with the first task, his attention was reported to be drawn by the appearance of cognitive tool and his curiosity was reported to increase because of its explanation about the knowledge embedded in the task. However, when the tool was presented once again after the second task, the participant reported to pay less attention and was not able to report whether he still felt curious about the explanation. As for the content of the game, the participant reported to feel interested in the storyline from the start and was keen to find out how the story would end. However, when doing the first task, he reported not to be able to see clearly how the task was relevant to the concept of ERM (Entity Relationship Modelling) in database modelling, but after the knowledge embedded in the task was made clear to him by the cognitive tool, he reported to have a wider view towards learning databases in a new environment other than a classroom setting.

## 7.3.3 Representations for Explaining the Motivation of Case Study 1

### 7.3.3.1 Explanatory Effects Matrix

A table of explanatory effects matrix was built according to the description in section 7.2.2.2 and is shown in Table 7.4. The table aims at displaying the overall picture of the relationships among three kinds of variables: trait characteristics, ILE features and state characteristic. The explanation of the table was also created based on existing literature (section 4.2.3) and evidence (data from post-questionnaire, self-report and semi-structured interview) which were considered to support the literature to some extent.

The table can be explained in the following fashion. The participant reported about his trait characteristics in a learning situation that he preferred to have a high control and he fancied challenge; also, he liked to be independent when learning, so, the participant was assigned by MoRes to play Alex's Adventure 2.0. In this version of the game, the participant could have a high control over the features: content and cognitive tool. That is, he could select which storehouse/wagon he preferred to start working with when doing each task in the game (content); he also could choose whether to receive an explanation from Mushyman after finishing with the tasks (cognitive tool). Furthermore, in case he made a mistake during the tasks, he had a choice whether to receive a feedback from the characters, Mary (in the first task) and James (in the second task). And, if he decided to do so, he would obtain guided feedback (a clue about what was wrong and what was supposed to be right) instead of direct feedback.

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state) | | Longer-Run Consequences (overall-state perspective) | |
|---|---|---|---|---|---|---|
| | | | **Direct Effects** | **Meta Effects** | **Initial States** | **Consecutive States** |
| | Instructional goal: Support Learning | | **Short-Term Relevance:** the goal was developed when the knowledge was clearly presented and it was achieved throughout the session | **Cognitive curiosity:** Increasing curiosity when progressing through the different scenes; dropping curiosity in the repetitive scenes **Effort:** Mostly, a high/very high effort used during interaction with the game; a low effort was reported to be used in the scenes that contain no activity /does not require much thinking **Confidence:** High/very high throughout the game | **Short-Term Relevance:** VH | **Cognitive curiosity:** H **Effort:** VH **Confidence:** VH |
| | Instructional goal: Provide Fun | | **Long-Term Relevance:** Participant's goal from the beginning and was achieved throughout the session | | **Long-Term Relevance:** H | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Short-Term Relevance:** Perceived the relevance between the tasks and the knowledge when doing the second task **Long-Term Relevance:** Felt fun with the game from the beginning | | **Short-Term & Long-Term Relevance:** VH | |
| | Cognitive Tool | Can choose to/not to receive the explanation from Mushyman | **Attention:** Drew the attention of the participant by the immediate appearance of the tool and its explanations | | **Attention:** VH | **Cognitive curiosity:** VH **Effort:** H(feedback)/ VH **Confidence:** H(cognitive tool)/VH |
| Challenge | Feedback | Guided feedback | **Attention:** Attract the participant by telling him about his performance in doing the tasks in the game | | **Attention:** H | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** Caught the participant's attention instantly throughout the game | | **Attention:** VH | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Felt the coherency in the story and perceived the knowledge embedded in the storyline | | **Short-Term & Long-Term Relevance:** VH | **Cognitive curiosity:** H **Effort:** VH **Confidence:** VH |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.4: Explanatory effects matrix of case study 1

As shown in the table, the instructional goals: support learning and provide fun, which were set when designing the game environment, were seen as affecting the relevance state of the participant directly. According to the data (see Figure 7.2 for the plot of relevance which was measured against two instructional goals), this case was likely to have the goal in having fun with the game from the beginning of the game, but it seemed that he did not have the goal in learning at the start; however, the goal in learning was reported to develop later during interaction (from snapshot 5 onwards as can be seen from the plot). Hence, it was considered that there seems to be two types of relevance: short-term relevance (the relevance state which did not occur immediately, but it rather developed later during interaction) and long-term relevance (the relevance state which occurred from the start of the interaction). At the end of the game, the participant reported to have a very high feeling of short-term relevance as he could learn the concepts about entity and attribute in the new environment (the goal in learning was achieved) and he also have a high feeling of long-term relevance as he enjoyed the story of the game (the goal in having fun was also fulfilled).

Content which refers to the storyline and the knowledge embedded in the game is another feature that was considered to directly affect the state of long-term relevance and of short-term relevance. As explained earlier, the participant was likely to have the goal in having fun from the beginning, but he seemed to have the goal in learning later in the game. When looking at the plot of relevance which was measured against content (see also Figure 7.2), it was considered that the content of the game was likely to be able to fulfill both goals of the participant. For example, from snapshot 5 onwards the participant reported to have a high feeling to learn from playing the game and he reported that the content (the second task and the explanations about the knowledge embedded in the tasks) of the game was highly relevant to his goal in learning. At the end of the game, the participant reported that he highly felt that the content of the game could fulfill his goals in learning and having fun (he gained knowledge from playing the game and the story was enjoyable to him).

Cognitive tool, feedback and imagery, on the other hand, are the features which were considered to have an effect on the attention state of the participant straightaway. As can be seen from the plot of attention which was measured against these three features (see Figure 7.1), the participant reported to be highly attracted to the imagery used in the game throughout the interaction. Similarly, the feedback given to the participant during the tasks and the use of cognitive tool to explain the knowledge embedded in the tasks could also draw his attention; however, the use of the same feedback style in both tasks resulted in the decrease in the participant's attention. When the participant was asked to report his overall attention, he reported to pay a very high attention to the imagery used in the game and the cognitive tool, but he paid slightly lower attention to the feedback since he always receive the same feedback in both tasks (the participant did the task very well and thus, he always received short praises as rewards).

Apart from causing the direct effect as previously explained, all these features were also considered to cause the meta effects[2]. Three motivational states were considered to be the meta effects caused by the ILE features: cognitive curiosity, effort and confidence. According to the data (see Figure 7.3 for the plot of cognitive curiosity, effort and confidence), the participant's cognitive curiosity started to increase as he

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[2] As already explained in section 7.2.2.1, the term 'meta effects' refers to the motivational states which were affected after the initial states (attention, long-term relevance and short-term relevance).

progressed through the game; however, his curiosity dropped slightly in the scenes that looked similar to those presented earlier (in terms of setting, etc.). Also, from the plot it seems that this motivational state did not occurred immediately from the beginning which was different from attention and long-term relevance (the participant seemed to feel attentive to the game and expected to have fun from the beginning). Furthermore, it was noticed that the value of cognitive curiosity, to some degree, related to the value of attention and of long-term relevance as can be seen from the plot of these motivational states, there are some similarities in some plot points. Based on this evidence, cognitive curiosity was considered to be the state that was likely to be affected after attention and long-term relevance.

The confidence state of the participant could be explained in a similar way. As can be seen from the plot of confidence (see also Figure 7.3), the participant started playing the game with a high confidence and his confidence level was increasing over time. According to this, it looks like it also takes some time for the confidence state to develop further. Also, we noticed that there are some similarities in the plot points among the plot of attention, the plot of relevance and the plot of confidence; thus, confidence was also considered to be the state that seemed to be affected after attention and long-term relevance.

As for the effort state, the participant reported to use a high effort from when he started playing the game. However, the level of his effort used in playing the game seemed to vary as he progressed through different scenes. We incline to explain that this might be because each scene contains different degrees of interaction which resulted in the use of different levels of effort – a higher effort was reported to be used in the scene that required more actions or lots of thinking from the participant. We also noticed that the value of effort, somehow, related to the value of attention and the value of both types of relevance; for example, in the ‘Opening & Invitation’ scene (snapshot 1 in Figure 7.3), some ILE features were not presented and several motivational states were reported to have a low/ very low value, but the participant reported to use a high effort in this scene and to pay high attention towards imagery used in the scene; similarly, in the ‘In the Forest’ scene (snapshot 2 in Figure 7.3), the participant reported to use a very high effort in completing the given activity and he also reported to feel highly fun when doing it. Based on these examples, effort was considered to be the motivational state that was likely to be affected after the participant was attracted by some features used in the game environment or felt that to some extent, the game was relevant to him and thus, effort was also considered to be the motivational state that was affected after attention and both long-term and short-term relevance. When the participant was asked to report his overall cognitive curiosity, effort and confidence, he reported to have a high cognitive curiosity towards the game and he made a very high effort and felt strongly confident when playing the game.

### 7.3.3.2 Case Dynamics Matrix

Four tables of case dynamics matrix were created according to the description in section 7.2.2.2 and are shown in Tables 7.5, 7.6, 7.7 and 7.8. The tables aim at displaying how the features of the game cause changes in the values of the participant's motivational states.

| **ILE Features** | | **Motivational States** | | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | |
| G: Support Learning | | **Short-Term Relevance:**<br>VL (#1)<br>N/A (#2 - #3) | **Cognitive curiosity:**<br>L (#1)<br>VH (#2 - #3)<br>**Effort:**<br>H (#1)<br>VH (#2)<br>L (#3)<br>**Confidence:**<br>H (#1)<br>VH (#2 - #3) | **For short-term relevance:**<br>- A very low value at the start<br>- Not applicable to report about the value in #2 and #3<br>**For long-term relevance:**<br>-A high/very high value throughout the stage<br>**For attention:**<br>- A high/very high value throughout the stage<br>**For cognitive curiosity:**<br>- Increasing value over time<br>**For effort:**<br>- A high level of effort used in #1 - #2<br>- A low level of effort used in #3<br>**For confidence:**<br>- Increasing value over time | **For short-term relevance:**<br>- Increased the feelings of short-term relevance by presenting the knowledge embedded in the game<br>**For long-term relevance:**<br>- Sustained the feelings of long-term relevance by including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>**For attention:**<br>- Maintained/Increased the level of attention by using more colourful graphics in the following scenes<br>**For cognitive curiosity:**<br>- Preserved the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Promoted the use of effort by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Kept the level of confidence by making use of the feature: content |
| G: Provide fun | | **Long-Term Relevance:**<br>VH (#1, #3)<br>H (#2) | | | |
| Content | | **Long-Term Relevance:**<br>VL (#1)<br>VH (#2)<br>N/A (#3) | | | |
| | Cognitive Tool | **Attention:**<br>AS (#1 - #3) | | | |
| Imagery | | VH (#1 - #2)<br>H (#3) | | | |
| | Feedback | AS (#1 - #3) | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.5: Case dynamics matrix 1: 'The Prelude' (snapshot 1 – snapshot 3) of case study 1

As can be seen from Table 7.5 (column: Underlying Issues (as seen by us)), the participant was highly attracted to the imagery used in this stage of the game and had a high feeling of fun from the beginning. His cognitive curiosity and confidence were also increasing over time and he reported to put a high effort when playing the game in the early scenes (snapshots 1 and 2); however, less effort was reported to be used in the last scene of this stage (snapshot 3). As for the feeling to learn, it looked as if the participant did not have the intention to gain knowledge from playing the game at the start; as can be seen from the values of short-term relevance, they were reported to be very low in snapshots 1 and 2, and in snapshot 3 the participant was not able to report the value of this motivational state. According to this, the strategies were specified in order to cope with these issues (column: How to Cope with). It was considered that the game environment could sustain/increase the level of attention and maintain the feeling of fun; the reason for why two choices of strategy were provided in order to cope with the attention state is because the value was reported to be high and did not reach its peak at the end of the stage (based on a five-point Likert scale), so it was possible for the attention level to be driven to the highest value; on the contrary, the feeling of fun (the value of long-term relevance) was reported to reach its peak (very high) at the end of the stage, and thus, only one strategy could be provided. In order to keep/raise the attention level, it was considered that more colourful graphics could be used in the following scenes and as for the feeling of fun, it was likely to be preserved by including more fun elements (e.g. surprised events, interactive activities, etc.) in the consecutive scenes. Apart from these two motivational states, the game should consider increasing the feeling to learn and raising the level of effort used in the next scene since the values of these two motivational states were reported to be low at the end of the stage. In order to do so, it was considered that the game could present the knowledge in a form of tasks to the participant to encourage him to learn from playing the game and to promote the use of a higher effort. In addition, the game could consider sustaining the level of cognitive curiosity and of confidence of the participant in the subsequent scene as they were reported to be very high at the end of this stage and to achieve this, the feature – content could be exploited.

Table 7.6 (column: How Issues in Matrix 1 Resolved) shows how the strategies explained earlier could be implemented in the game environment and thus, our game prototype was unfolded[3] in order to serve this purpose. The first task was given to the participant and at the end of the task, he was given an explanation about the ERM knowledge embedded in the task. The revelation of the first task and the explanation aimed at increasing his feeling to learn, sustaining the feeling of fun and his cognitive curiosity and promoting the use of a higher effort in playing the game. Also, during the task, the participant was given a short praise for every correct choice and a guided feedback for the wrong choices. The feedback given with regards to his performance aimed at strengthening his confidence. The colourful scenes and the funny look of the cognitive tool (the feature that provides the explanation about the ERM knowledge embedded in the game) were also used in order to keep/raise his high level of attention. As a result of this implementation, the values of the participant's motivational states were affected as shown in the column: Underlying Issues (as seen by us). The participant

[3] The term 'unfold' refers to the use of our game prototype as an example that implemented the anticipated changes in the game features according to the specified strategies.

did not seem to perceive that the task was involved with some concepts in ERM which resulted in the report of a low feeling to learn; however, when he was given the explanation about the task, the feeling was reported to increase sharply to a very high level. Apart from this, the feeling of fun was also sustained similar to his attention, cognitive curiosity and confidence. A low effort was reported to be used when doing the task; however, a high effort was reported to be used when the explanation was given. Based on these issues, the strategies were specified as can be seen from the column: How to Cope with. It was considered that another task could be given in order to maintain his feeling to learn and his feeling of fun with the game. Also, the task should not be too difficult to sustain his high confidence, but it should be different from the first task to create the feeling of curiosity and to preserve the very high level of effort used at the end of this stage. In addition, the imagery used in the second task could be changed in order to attract the participant’s attention.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">How Issues in Matrix 1 Resolved:</th><th rowspan="2">Underlying Issues (as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Short-Term Relevance:<br>L (#4)<br>VH (#5)</td><td rowspan="6">Cognitive curiosity:<br>H (#4 - #5)<br>Effort:<br>N/A (#4)<br>VH (#5)<br>Confidence:<br>VH (#4)<br>H (#5)</td><td rowspan="6">For short-term relevance:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For long-term relevance:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For attention:<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>For cognitive curiosity:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For effort:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For confidence:<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4)</td><td rowspan="6">For short-term relevance:<br>- A low value at the start of this stage<br>- A very high value at the end of the stage (Increasing value from the previous stage)<br>For long-term relevance:<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>For attention:<br>- A high/very high attention paid to different game features throughout the stage (Maintaining value from the previous stage)<br>For cognitive curiosity:<br>- A high level of curiosity throughout the stage (Small drop in value, but still in the positive level compares to the previous stage)<br>For effort:<br>- Not applicable to report about the effort used in #4<br>- A very high level of effort used in #5 (Increasing use of effort from the end of the previous stage)<br>For confidence:<br>- A high/very high confidence throughout the stage<br>(Preserving value from the previous stage)</td><td rowspan="6">For short-term relevance:<br>- Sustained the feelings of short-term relevance by giving another task to do<br>For long-term relevance:<br>- Maintained the feelings of long-term relevance by giving another task to do<br>For attention:<br>- Preserved the level of attention by making use of the feature: imagery<br>For cognitive curiosity:<br>- Sustained/Increased the level of curiosity by giving another task which should be slightly different from the first task<br>For effort:<br>- Kept the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>For confidence:<br>- Maintained/Increased the level of confidence by giving another task which should not be too hard compared to the first task</td></tr>
<tr><td>G: Provide Fun</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>L (#4)<br>VH (#5)</td></tr>
<tr><td>Cognitive Tool (#5)</td><td>Cognitive Tool (#4)</td><td>Attention:<br>AS (#4)<br>VH (#5)</td></tr>
<tr><td>Imagery</td><td></td><td>VH (#4 - #5)</td></tr>
<tr><td>Feedback (#4)</td><td>Feedback (#5)</td><td>H (#4)<br>AS (#5)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.6: Case dynamics matrix 2: ‘The First Task’ (snapshot 4 – snapshot 5) of case study 1

| ILE Features | | Motivational States | | How Issues in Matrix 2 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Short-Term Relevance:**<br>H (#6)<br>VH (#7) | **Cognitive curiosity:**<br>L (#6)<br>N/A (#7)<br>**Effort:**<br>N/A (#6)<br>VH (#7)<br>**Confidence:**<br>VH (#6)<br>H (#7) | **For short-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For short-term relevance:**<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>**For long-term relevance:**<br>- A high/very high value throughout the stage (Maintaining value from the previous stage)<br>**For attention:**<br>- A low attention towards feedback; A high attention towards imagery (#6)<br>- A high attention towards cognitive tool and imagery (#7) (Preserving value at the end of this stage)<br>**For cognitive curiosity:**<br>- A low level of curiosity at the start of this stage (#6)<br>- Not applicable to report about the level of curiosity at the end of the stage (#7) (Decreasing curiosity from the previous stage)<br>**For effort:**<br>- Not applicable to report about the effort used in #4<br>- A very high level of effort used in #5 (Increasing use of effort from the end of the previous stage)<br>**For confidence:**<br>- A high/very high confidence throughout the stage (Sustaining value from the previous stage) | **For short-term relevance:**<br>- Sustained the feelings of short-term relevance by making use of the feature: content<br>**For long-term relevance:**<br>- Maintained the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Preserved/Increased the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Raised the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Sustained/Increased the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>H (#6)<br>VH (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>H (#6)<br>H (#7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>H (#7) | **Cognitive curiosity:**<br>L (#6)<br>N/A (#7)<br>**Effort:**<br>N/A (#6)<br>VH (#7)<br>**Confidence:**<br>VH (#6)<br>H (#7) | | | |
| Imagery | | H (#6 - #7) | | | | |
| Feedback (#6) | Feedback (#7) | L (#6)<br>AS (#5) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.7: Case dynamics matrix 3: ‘The Second Task’ (snapshot 6 – snapshot 7) of case study 1

Table 7.7 (column: How Issues in Matrix 2 Resolved) shows how the strategies described in the previous matrix could be implemented in the game environment by taking our game prototype as an example. The participant was given the second task and the explanation after the task was finished. The second task aimed at sustaining the feeling to learn and the feeling of fun with the game. Also, it was expected to be able to maintain/increase his high level of cognitive curiosity and to preserve the very high level of effort used from the previous stage. Similar to when the participant did the first task, the feedback regarding his performance was given in order to strengthen his confidence. The change in the scene theme was also done to maintain his high attention. Indeed, the values of the participant’s motivational states were affected as a result of this implementation (see column: Underlying Issues (as seen by us)). His feeling to learn and his feeling of fun were preserved to be at a high level throughout this stage and his high confidence was also sustained. However, the participant reported to pay low attention to the feedback given to him during the second task; his cognitive curiosity was also reported to be low when he was doing the task and he was not able to report how much effort he put on doing the task. It was considered that the decrease in the value of these motivational states might be because of the similarity in both tasks and the use of the same feedback style. However, this did not seem to be the case for the explanation relating to the second task since the participant still reported to pay high attention and use a high effort in understanding it. According to these issues, the strategies were specified as shown in the column: How to Cope with. It was considered that the game could sustain the feeling to learn and the feeling of fun with the game; his high confidence could also be maintained as well as the high level of effort used in playing the game. To achieve this, the feature – content could be exploited by either offering a whole new task or continuing the story. However, the selection of the choice should be done with regards to the value of cognitive curiosity and since the participant reported to have a low curiosity in this stage, the value was supposed to be increased in the next stage. As a result, it was considered that the game could better decide to continue the story rather than offering the new task since the main aim of the prototype development was to use it as an instrument to extract the motivational data and thus, the prototype was created in such a way that it covered only some concepts in ERM; offering the new task could be done, but the prototype needed to be technically changed and we also had to include other complicated concepts (e.g. relationships) in which they are not the aim of our research; working on the story was considered to be a potential alternative since a review of the literature (as appeared in chapter 3) suggests that narratives (stories) can have a strong impact on motivation of a learner. Furthermore, the feature – imagery, was considered to be utilised in order to keep/raise the high level of attention of the participant.

| ILE Features | | Motivational States | | How Issues in Matrix 3 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G:<br>Support<br>Learning | | **Short-Term Relevance:**<br>VH | **Cognitive curiosity:**<br>VH<br>**Effort:**<br>H<br>**Confidence:**<br>H | **For short-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene – Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For short-term relevance:**<br>- A very high value throughout the stage (Sustaining value from the previous stage)<br>**For long-term relevance:**<br>- A high/very high value throughout the stage (Maintaining value from the previous stage)<br>**For attention:**<br>- A high attention paid in this stage (Preserving value from the previous stage)<br>**For cognitive curiosity:**<br>- A very high level of curiosity in this last stage (Increasing curiosity from the previous stage)<br>**For effort:**<br>- A high level of effort used in this stage (Small drop in value, but still in the positive level compares to the previous stage)<br>**For confidence:**<br>- A high confidence in this stage (Sustaining value from the previous stage) | - Resulted in satisfying outcome – the participant was finally motivated to learn with the game environment |
| G:<br>Provide<br>Fun | | **Long-Term Relevance:**<br>VH | | | | |
| Content | | **Long-Term Relevance:**<br>H | | | | |
| | Cognitive Tool | **Attention:**<br>AS | | | | |
| Imagery | | H | | | | |
| | Feedback | AS | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.8: Case dynamics matrix 4: 'The Finale' (snapshot 8) of case study 1

Table 7.8 (column: How Issues in Matrix 3 Resolved) shows how the strategies explained in the earlier matrix could be implemented in the game environment (considering our game prototype as an example). The ending of the story was revealed – the main character completed the mission successfully. The revelation of the ending aimed at maintaining the high feelings of long-term relevance as well as the high level of confidence of the participant. Also, it was supposed to be able to raise his cognitive curiosity to a high/very high level in this stage. The colourful scene (as appeared in snapshot 8), presented earlier in the game, was shown once again to attract the attention of the participant (by making him guess what would happen next) and to encourage the high level of effort used from the previous stage (the participant could explore the scene if he wanted to do so). As a result of this implementation, the values of all motivational states were reported to be high/very high in this stage and when the participant was asked to report his overall motivation at the end of the game, he reported to be motivated to both learn and play with the game ILE which was the satisfying outcome.

### 7.3.3.3 The Revised Causal Model

The revised causal model of motivation of the case was produced according to the description in section 7.2.2.2 and is shown in Figure 7.4. The model aims at presenting two kinds of variable: the ILE features and the motivational variables, and the relationships among them in a more coherent picture – a form of network. The motivational variables and the ILE features are represented by nodes whereas the relationships among them are represented using links. A link was drawn from the starting node to the target node which means the value of the starting node will cause a change in the value of the target node, either increasing the value or decreasing it. Also, between any two nodes, it is possible to have two links with different directions. That is to say it is possible to have a link drawn from node A to node B (which means the value of node A can cause a change in the value of node B) and at the same time it is possible to have another link drawn from node B to node A (which means the value of node B can also cause a change in the value of node A). This situation was considered to be able to happen, especially in the case of the relationship between the ILE features and the motivational states (The features of the game ILE can cause a change in the values of the relevant motivational states, either increasing the value or decreasing them and in case the values of those motivational states are decreased, the features of the game are supposed to change in order to raise their values.

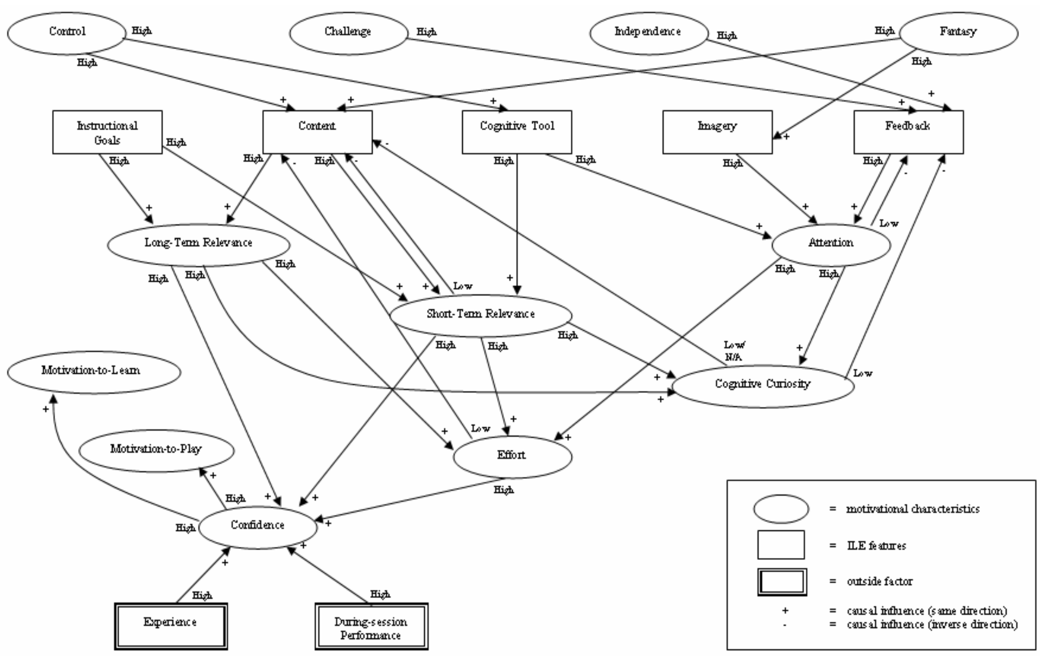


Figure 7.4: The revised causal model of motivation of case study 1

The story of the revised model can be told as two related parts. The first part of the story demonstrates the relationships between the trait characteristics of the participant (independent variables) and the features of the game ILE (dependent variables that vary according to the trait characteristics). The story of this part starts when the participant reported about his trait characteristics in a learning situation that he would like to have a high control over materials and he fancied challenging situations. Also, he preferred to be independent when learning (that is, he wanted to succeed by himself without asking for help from a tutor); thus, he was assigned to play Alex's Adventure 2.0 where he could control some parts of the game content including the cognitive tool. In our game prototype, being able to control the cognitive tool was considered to be a part of allowing the participant to have control over the content because his decision in using the tool could have an effect on the story – if he decided not to use the tool, he would be directed to a specific scene (which would not be presented if he decided to use the tool). Furthermore, the participant was given a choice in receiving feedback when he made a mistake during the tasks and the type of feedback given to him was designed to be the guided feedback instead of the direct feedback as the first kind was considered to be more challenging. The design described so far attempts to make the game better matched with the high-control, high-challenge and high-independent characteristics of the participant.

The second part of the story shows the relationships between the features of the game and the state characteristics of the participant. The ILE features in this part can be viewed as both the independent and dependent variables. They can be seen as the independent variables when they cause changes in the value of the related state characteristics (motivational states); on the other hand, they are the dependent variables when they need to be changed in order to raise the value of the associated motivational states. Similarly, the state characteristics can be viewed as both the independent and dependent variables. They can be seen as the independent variables when they cause changes in the value of the associated motivational states; on the contrary, they are the dependent variables when they are influenced by other related motivational states. The story of this part begins when the participant started to interact with the game environment.

According to the data (see Figure 7.1 for the plot of attention, Figure 7.2 for the plot of relevance and Figure 7.3 for the plot of cognitive curiosity, effort and confidence), there are fluctuations in the graphs appeared in those plots which means the values of the participant's motivational states can vary according to the scenes presented. Indeed, there are some similarities and some differences among these scenes;

thus, some of them may contain the same features and some of them may consist of different features. Based on this piece of information, it was considered that the features included in a single scene could play an important role in the change in the value of the motivational states. In other words, the features of the game environment could exert some influences on the motivational states of the participant.

According to the plot of attention, the use of imagery in the game ILE could attract the participant's attention instantly throughout the interaction as well as the use of cognitive tool; thus, two links were drawn from the features: imagery and cognitive tool, to attention. The use of feedback was able to draw the attention of the participant when it was given in the first task (snapshot 4 in Figure 7.1), but in the second task this did not seem to be the case (snapshot 6 in Figure 7.1); as a result, a link was drawn from the feature – feedback, to attention to represent the relationship occurred in the first task and another link was drawn backward from attention to the feature – feedback, to represent the relationship occurred in the second task (which means the feedback could be adjusted in order to raise the attention of the participant).

Furthermore, as can be seen from the plot of relevance (Figure 7.2), the participant reported to have a feeling of fun from the start to the end of the game and this demonstrates the correspondence between one of the instructional goals (provide fun) and the goal of the participant in having fun with the game; this correspondence was regarded as long-term relevance since the goal in having fun occurred from the start. However, as for the feeling to learn from the game of the participant, it was reported to develop when the explanation about the ERM knowledge embedded in the task was given by the cognitive tool (snapshot 5 in Figure 7.2) and this demonstrates the correspondence between the instructional goal – support learning, and the goal of the participant to learn by playing the game (even though the goal was reported to develop later); this correspondence was regarded as short-term relevance since the goal in learning occurred later during interaction. Based on this evidence, the motivational state – relevance (in the preliminary model) was divided into two sub-states: long-term relevance and short-term relevance as shown in Figure 7.4. A link was drawn from the feature – instructional goal, to both long-term and short-term relevance to represent the relationship (or the match) between two instructional goals (support learning and provide fun) and the long-term and short-term goals of the participant. It was considered that a link could also be drawn from the feature – content, to both long-term and short-term relevance since this feature was considered to play an important role in sustaining the participant's feelings of long-term relevance and influencing the development of his feelings of short-term relevance. A backward arrow was also drawn from the short-term relevance to the feature – content, to represent the idea obtained from the analysis of this case that in case a student does not have the goal in learning at the beginning of the instructional interaction (no feelings that this goal is relevant in long-term), the feelings of short-term relevance are supposed to be created instead (the feelings that the goal in learning is relevant in short-term) similar to what happened to this case study. As can be seen from Figure 7.2 (the plot of relevance value which was measured against the features: instructional goals and content), the feelings that the game was relevant to his goal in learning were reported to occur in snapshot 5 and it was reported to be at a very high level in both snapshots 5 and 7 where the cognitive tool was presented. As a result, another arrow was drawn from the feature – cognitive tool, to short-term relevance to show the effect of the tool on this motivational state.

There are the other three motivational states: cognitive curiosity, effort and confidence, which were considered to be affected by either attention or relevance, or both, according to the literature described in section 4.2.3. Based on the literature and looking from the plot of cognitive curiosity, effort and confidence (Figure 7.3), the plot of attention (Figure 7.1) and the plot of relevance (Figure 7.2), the participant's curiosity was considered to be driven by attention and both long-term and short-term relevance. As can be seen from those plots, when the value of attention and of relevance fall into the high-value area (Attention/Relevance Value = 4 and Attention/Relevance Value = 5), generally, the value of cognitive curiosity falls into the same area. However, there is a point in the graph in which the value of cognitive curiosity drops to a low level and another point where the participant was not able to report his curiosity (snapshots 6 and 7, respectively). But, this did not seem to cause a strong effect on his curiosity level at the end of game since the value of this motivational state could be raised by adjusting the content of the game as can be seen from case dynamics matrix 4 (column: Underlying Issues) that presents the results after the adjustment. Also, it was considered that the feedback given during the second task could be adjusted since the participant reported to feel low curious when this feature was provided in the second task. Based on this evidence, three links were drawn from three motivational states: attention, long-term relevance and short-term relevance to cognitive curiosity, to represent the relationships among these motivational states, and also, two links were drawn backward from cognitive curiosity to the features: content and feedback, to represent the situations that occurred in snapshot 6 to snapshot 8.

Similarly, the participant's effort used in playing the game was considered to be influenced by attention and both long-term and short-term relevance (based on the literature described in section 4.2.3). As can be seen from the plot of cognitive curiosity, effort and confidence (Figure 7.3), the plot of attention (Figure 7.1) and the plot of relevance (Figure 7.2) that generally, there are similarities among the value of effort, of attention and of relevance even though at some specific points in the game the value of each of these motivational states is not exactly the same (snapshots 3, 4 and 6). A low effort was reported to be used in snapshot 3 in which the presented scene did not involve any activity/task (the scene was created aiming to make the story flow). Also, the participant was not able to report the level of effort used in snapshot 4 and snapshot 6 where both tasks were given; we incline to explain these incidents occurred because the participant could perform the tasks very well even though he played this kind of game for the first time and thus, he might feel that he put effort on the tasks and thus, the values of effort were not low; however, they were not high either since the tasks were not too complicated for him and as a result, he might feel slightly reluctant to report the level of effort he used in doing the tasks. However, a very high level of effort was reported to be used in snapshot 5 and snapshot 6 where the knowledge embedded in the tasks was explained directly to him. According to this evidence, three links were drawn from attention, long-term relevance and short-term relevance to effort to represent the relationships among these motivational states; also, another link was drawn backward from effort to the feature – content, to represent what was done to the game in order to promote more use of effort.

Confidence is the motivational state in the model which requires a slightly different explanation. From the plot of cognitive curiosity, effort and confidence (Figure 7.3), the plot of attention (Figure 7.1) and the plot of relevance (Figure 7.2) and according to the literature described in section 4.2.3, confidence is the motivational state in which its values, generally, were considered to be influenced by three motivational states: long-term relevance, short-term relevance and effort; however, there were some points in the game (e.g. snapshots 4 and 6) where the participant reported to have a very high confidence, but he reported to have different values for long-term relevance, short-term relevance and effort. As a result, it was considered that the values of confidence at these points might be influenced by other factors which were not included in our preliminary model; these factors were termed as ‘outside factors’ since they cannot be categorised as neither the motivational characteristics nor the ILE features. We considered that the factor that were likely to have an influence on confidence are: during-session performance and experience; based on the observational notes, the participant performed very well in both tasks and it was considered that he could gain some experience from doing the first task which might be the reason why he reported to feel very high confident in doing the following tasks. Based on the explanation so far, three links were drawn from long-term relevance, short-term relevance and effort to confidence and also, the other two links were drawn from during-session performance and experience (represented by double-line boxes) to confidence in order to represent the relationship between the outside factors and the motivational state – confidence.

### 7.3.4 Summary of Case Study 1

This case can be regarded as a normal 'motivated' case since the participant reported to be motivated to learn after the session with the game prototype was finished.

The participant was asked to provide the trait characteristics in a learning environment and based on his report, MoRes assigned him to play Alex's Adventure 2.0 which was considered to be the proper version that suit with his traits. His trait characteristics are shown in Table 7.1. After the interaction with the game was finished, the participant was asked to report his motivational states during interaction and his overall motivational states at the end of the interaction. The data regarding the motivational states of the case during interaction was presented using the event listing table (Table 7.2) and three plots of motivational states (Figures 7.1 – Figure 7.3). The effects matrix of ILE features (Table 7.3) was employed in order to describe the effects of the game features on the motivational states of the case. The causal mechanisms between the trait characteristics of the case, the features of the game ILE and the state characteristics of the case were exposed using the explanatory effects matrix[4] (Table 7.4) and four case dynamics matrices (Table 7.5 – Table 7.8). The revised causal model of motivation of the case was also built to present these causal mechanisms in a coherent picture (Figure 7.4).

Some major findings can be drawn from the study of this case:

- The motivational state – relevance, can be divided into two types: long-term relevance and short-term relevance. The long-term relevance refers to the correspondence between the instructional goal (provide fun) and the goal of the participant (have fun) that occurs from the start of the instructional interaction whereas the short-term relevance refers to the correspondence between the instructional goal (support learning) and the goal of the participant (learn from playing the game) that occurs later during interaction.

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[4] The explanatory effects matrix also presents the data regarding the overall motivational states of the case at the end of the interaction.

- The motivation to learn in the educational game context could be occurred by adjusting the content of the game (e.g. changing the way the knowledge was presented) to influence the participant's feeling to learn by playing the game (short-term relevance).
- To raise the level of attention, the feature – feedback, could be adjusted (e.g. changing the feedback style regarding the participant's performance).
- To raise the level of cognitive curiosity, the features: feedback and content, could be adjusted (e.g. offering a more challenging task, changing a storyline by offering more branches).
- To increase the level of effort used in the game ILE, the feature – content, could be adjusted (e.g. creating a task that require more actions or thinking).
- Confidence was the motivational state that might be influenced by the outside factors: during-session performance and experience; however, it was not evident whether these factors could also influence the other motivational states

## 7.4 Case Study 6: Case E09

### 7.4.1 Background of Case Study 6

The participant is a female gender whose age is below 20 years old. She is a British student and is doing her first degree in computing science. She has some knowledge in database modelling and had experience in creating a database using database software – Microsoft Access. She also reported to enjoy playing computer games and has played several kinds of games (e.g. Tetris, first person shooters, adventure games, etc.). At the start of the session with our computer program – MoRes, the participant was asked to provide the data about some of her trait characteristics in a learning environment. These characteristics are shown in Table 7.9.

Based on her trait characteristics, MoRes assigned her to play Alex's Adventure 4.0[5].

| Control | Challenge | Independence | Fantasy |
|---|---|---|---|
| High | Low | High | High |

Table 7.9: Trait characteristics of case study 6

[5] The specifications of Alex's Adventure 4.0 were described in section 5.3.1.4.

However, after the participant finished playing the game she reported not to feel motivated to learn from playing this version of the game and thus, she was asked to play the adjusted version of Alex's Adventure 4.0 (Alex's Adventure 8.0). The motivational data of the participant from the interaction with the two games are presented alongside each other in order to show changes in the values of the motivational states when playing the first and the second game, accordingly. The term 'first play' and 'second play' may appear in the following sections and they refer to the time when the participant played the first game (Alex's Adventure 2.0) and the second game (the adjusted version of Alex's Adventure 2.0), respectively. The term will also be used in the analysis of case study 4 (Appendix E) and 5 (Appendix F).

### 7.4.2 Representations for Describing the Motivation of Case Study 6

#### 7.4.2.1 Event Listing of Motivational State

Table 7.10 displays the values of the motivational states of the case when playing the first game. The table was created based on the data reported through the use of retrospective self-report.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Attention** | **Imagery** | L | H | H | L | H | L | H | H |
| | **Feedback** | AS | AS | AS | H | AS | H | AS | AS |
| | **Cognitive Tool** | AS | AS | AS | AS | L | AS | L | AS |
| **Relevance** | **Content** | L | H | VH | H | H | H | H | H |
| | **Goal: Support Learning** | L | L | VH | H | L | H | L | L |
| | **Goal: Provide Fun** | L | VL | H | VL | L | VL | L | L |
| **Cognitive Curiosity** | | L | L | H | L | L | L | L | H |
| **Effort** | | H | H | H | H | L | H | L | H |
| **Confidence** | | H | H | L | L | L | L | L | L |

Legend:
VL = Very Low
L = Low
N/A = Not Applicable
H = High
VH = Very High
AS = Absent feature from the scene

Table 7.10: Event listing of motivational state of case study 6 (first play)

According to the data shown in the table and our observational notes, the participant reported to have a low interest in playing the game when seeing the opening scene. She also reported to have a low curiosity towards the game after finishing reading the introduction to all characters in the game. However, when the 'In the Forest' scene was presented, the participant reported to be attracted by the imagery used in the scene (looked over the screen **(:G1)**) and she seemed to pay attention to the conversation between the characters appeared in the scene (stared at the scenes all the time and moved her top body closer to the screen **(:G2)**). Nevertheless, when she was asked to find all hidden mushrooms in the forest to progress through the next scene, she reported not to feel fun nor curious to finish this activity. However, she reported to use a high level of effort and felt highly confident when doing the activity. After she collected four mushrooms and saw the scene was changing, she seemed to feel satisfied **(:F1)**. When the next scene was presented, the participant reported that her attention was drawn by the appearance of the other two characters – Dr de Ville and Mary and she seemed to be interested in the conversation among the characters appeared in this scene (**(:G2)**; seemed to think along **(:G3)**). Also, the participant reported to have a high cognitive curiosity and used a high level of effort in this scene. In the following scene – the 'First Task' scene, the participant reported to feel less attracted to the imagery used in the scene. However, she reported to pay high attention to the feedback given when she was doing the first task and she used a high effort in doing the task (check the information kept in the chests before choosing which one she was going to move **(:G4)**). She also reported to be able to see the database knowledge embedded in the task; however, in her opinion the task was not enjoyable. The participant performed very well in the task and after the first task was finished, she reported that it did not make her felt more confident to move on to the next task. In the 'Meet Mushyman #1' scene the participant reported to be attracted by the appearance of the character, Mushyman. However, she reported to pay low attention to its explanation about the knowledge embedded in the task. Also, she reported to have a low curiosity towards the explanation and used a low effort in trying to understand it. Furthermore, she reported that the explanation did not make her felt more confident in doing the following task. In the 'Second Task' scene and the 'Meet Mushyman #2' scene the participant reported to have the same feelings as in the 'First Task' scene and the 'Meet Mushyman #1' scene. However, she seemed to play the game by guessing nearly at the end of the second task. In addition, when she saw Mushyman after the second task was finished, she chose not to receive the explanation at first, but when she was told that she needed to walk pass the dark forest if she decided to do so, she, then, changed her mind. However, it seemed that she did not pay attention to the explanation about the second task as she clicked a button to close the dialog boxes quickly. In the last scene the participant reported to be attracted by the imagery used in the scene even though it was presented for the second time. Furthermore, she reported to feel curious about how the story would end. At the end of the game, she reported to feel a high coherency in the story and used a high effort when playing the game. However, she reported not to gain any ERM knowledge from doing the tasks in the game and she also reported to have a low feeling of fun when playing.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Attention** | **Imagery** | L | H | H | L | H | L | H | H |
| | **Feedback** | AS | AS | AS | H | AS | L | AS | AS |
| | **Cognitive Tool** | AS | AS | AS | AS | L | AS | L | AS |
| **Relevance** | **Content** | H | H | H | H | H | H | H | H |
| | **Goal: Support Learning** | H | L | H | H | L | H | L | L |
| | **Goal: Provide Fun** | L | L | H | VL | L | VL | L | L |
| **Cognitive Curiosity** | | L | L | H | L | L | L | L | L |
| **Effort** | | H | L | H | H | L | H | L | H |
| **Confidence** | | L | H | L | L | L | L | L | L |

Legend:
VL = Very Low
L = Low
N/A = Not Applicable
H = High
VH = Very High
AS = Absent feature from the scene

Table 7.11: Event listing of motivational state of case study 6 (second play)

Table 7.11 displays the values of the motivational states of the case when playing the second game (the adjusted version of the first game). The participant reported to have similar level of attention towards the imagery as when she played the first game even though she could spot some changes in the graphics used in the second game. However, her attention paid to the feedback given during the second task was reported to drop to a low level in the second game. As for the feeling to learn, the participant seemed to have the goal in learning at the start of the second game as she reported to feel interested to know what knowledge she could learn from playing this game. However, as she progressed through the second game, she reported to have the similar feelings towards learning as when she played the first game. According to her report, she was able to see the knowledge embedded in the tasks, but, she was not happy with the explanations about the tasks. Furthermore, her feeling of fun was reported not to be different from those in the first play. In addition, the participant reported to have the same level of curiosity as when she played the first game and to use the similar level of effort in playing the second game. However, a low effort was reported to be used when doing the same activity (in the ‘In the Forest’ scene) as in the first game. As for her confidence, she reported to feel the same as when she played the first game.

### 7.4.2.2 Plot of Motivational State

Six plots of motivational state were developed as described in section 7.2.2.1 and are shown below. The first two plots (Figures 7.5 and 7.6) are the plots of attention in the first and the second play. The next two plots (Figures 7.7 and 7.8) are the plots of relevance in the first and the second play and the last two plots (Figures 7.9 and 7.10) are the plots of three motivational states: cognitive curiosity, effort and confidence, in the first and the second play.

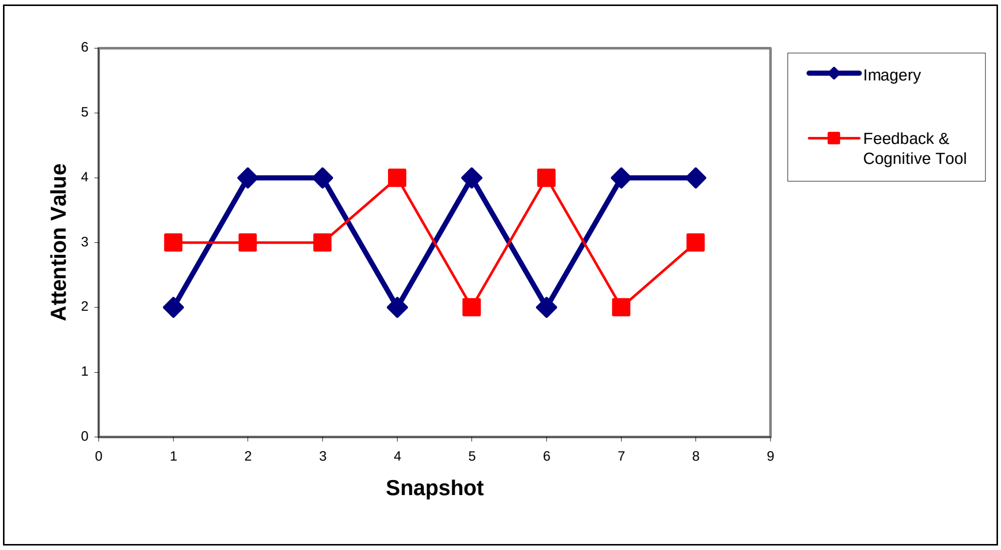


Figure 7.5: Attention value towards three features of the game during the first play

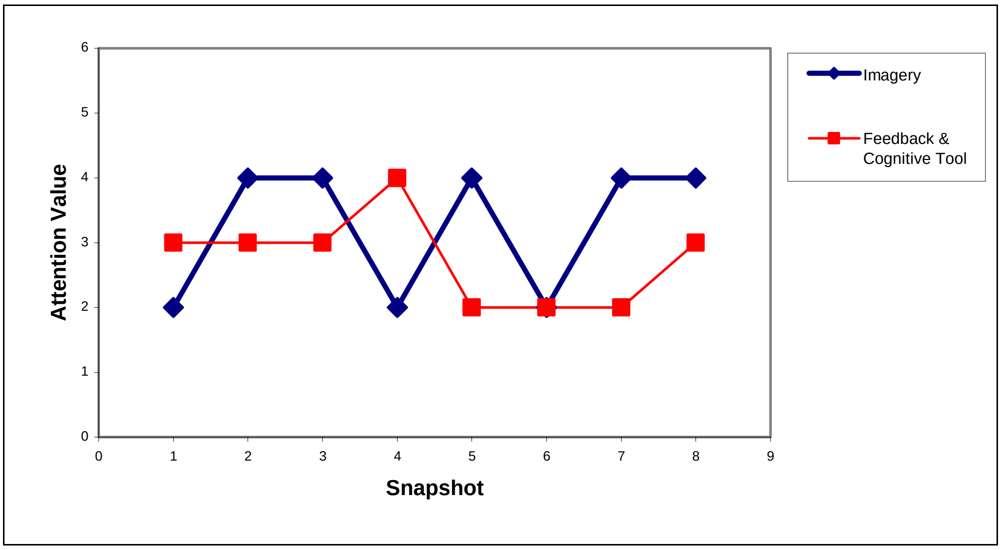


Figure 7.6: Attention value towards three features of the game during the second play

Figure 7.5 shows the values of the participant's attention towards three features of the game (imagery, feedback and cognitive tool) in the first play whereas Figure 7.6 shows the values of the attention towards these features in the second play. According to the figures, the participant's attention paid to the imagery used in both games was reported to vary between the value of low and of high (Attention Value = 2 and Attention Value = 4). The attention of the participant was reported to be low when the participant was asked whether she could spot anything interesting in snapshot 2 ('In the

Forest' scene), snapshot 4 ('The First Task' scene) and snapshot 6 ('The Second Task' scene) in both games. As for the attention towards the feature – feedback, the participant reported to pay high attention when it was given during both tasks of the first game; however, a low attention was reported when it was given during the second task of the second game. As for the attention towards the feature – cognitive tool, the participant reported to pay low attention when it was presented in both games.

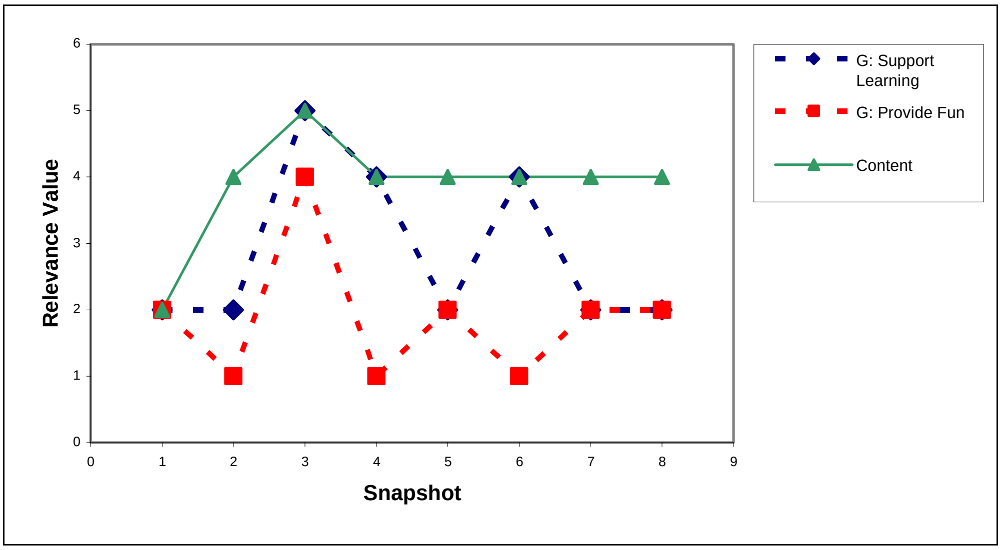


Figure 7.7: Relevance value towards two features of the game during the first play

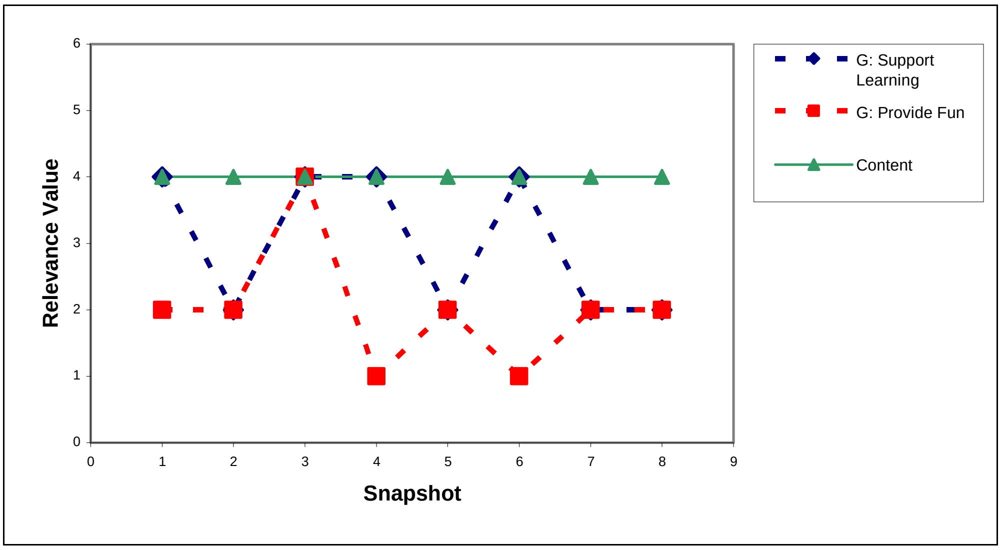


Figure 7.8: Relevance value towards two features of the game during the second play

Figures 7.7 and 7.8 show the participant's feelings of relevance towards two features of the game: instructional goals (support learning and provide fun) and content in the first and the second play, respectively. According to the figures, it seem that the participant did not have the feeling to learn when she played the first game even though she reported to be able to see the ERM knowledge embedded in the task. However, she reported to be interested to know what knowledge she could learn when she started playing the second game. Similar to what happened in the first game, as she progressed through the game, she reported to be able to see the knowledge embedded in the tasks, but she was not happy to learn from it. As for her intention to have fun when playing the game, the participant generally reported to feel a high coherency in the storyline, but it could not fulfil her goal in having fun and thus, she generally reported to have a low feeling of fun when playing both games.

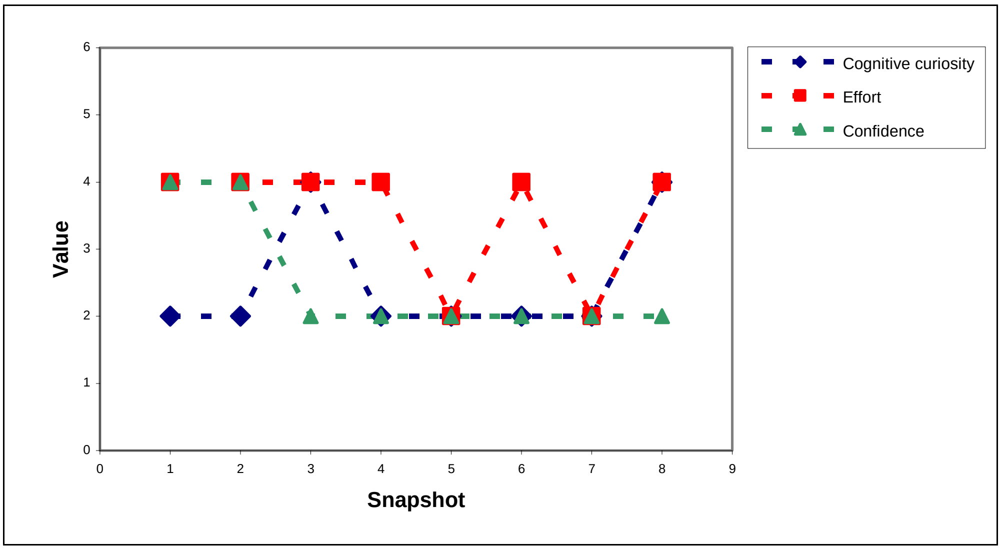


Figure 7.9: The value of cognitive curiosity, of effort and of confidence during the first play

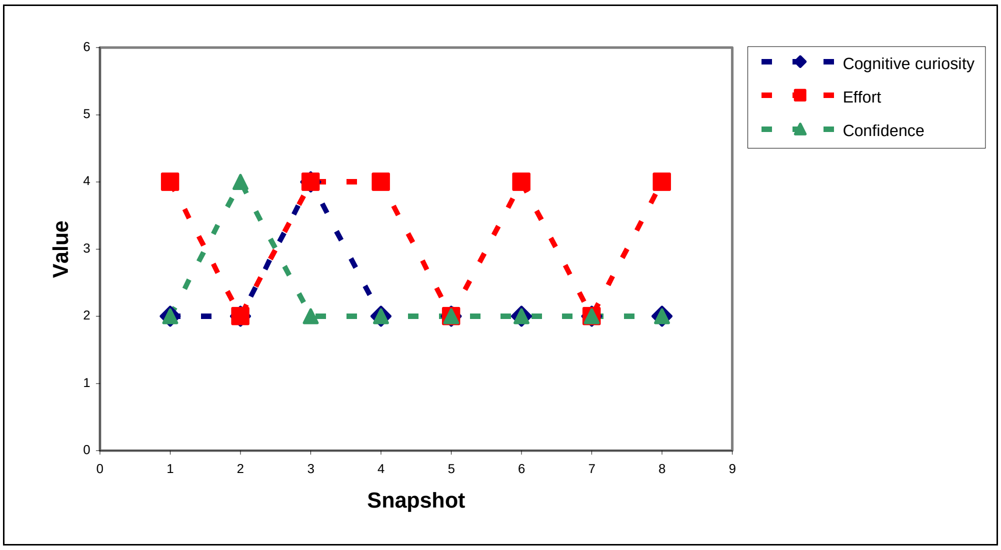


Figure 7.10: The value of cognitive curiosity, of effort and of confidence during the second play

Figures 7.9 and 7.10 show the values of the following motivational states during interaction with both games: cognitive curiosity, effort and confidence. According to the figures, it seems that generally, the participant reported to have a low curiosity when playing both games. However, she reported to have a high curiosity when she was told that she needed to do some tasks in the games (snapshot 3). Also, she reported to feel curious about the ending of the first game, but this did not seem to be the case when she played the second game since she reported that she could guess how the second game would end. As for effort, the participant reported to use a high effort in playing both games except when she was given the explanations about the knowledge embedded in the tasks and when she was asked to complete the same activity (finding all hidden mushrooms in the 'In the Forest' scene) as when she played the first game. As for confidence, the participant reported that she felt highly confident when she started playing the first game. However, after she progressed through the game, she reported that the tasks and the explanations presented in the game did not make her felt more confident. In the second game the participant reported to have a low confidence at the beginning; however, her confidence was reported to increase in the following scene when she was asked to complete the same activity as she did in the first game. After that she reported to have the same level of confidence as when she played the first game (the tasks and the explanations presented in the game did not make her felt more confident).

#### 7.4.2.3 Effects Matrix of ILE Features

Table 7.12 describes the effects of the game features on the motivational states of the participant in the first and the second play. A single table was built as it was considered that the first and the second game are quite similar (only some changes were made to the imagery used in the second game). This was also done when analysing the other two non-motivated cases – case study 4 (Appendix E) and case study 5 (Appendix F).The description of the table was also created and shown below.

According to the table, the use of colourful scenes and the immediate appearance of the cognitive tool in both games could attract the attention of the participant straightaway. Nevertheless, the participant reported to pay low attention to the 'First Task' and the 'Second Task' scene as she reported not to be able to spot anything interesting in these scenes in both games. When the participant was given the feedback about her performance during both tasks of the first game, she reported to pay high attention to it. However, this did not seem to be the case when the feedback was given during the second task of the second game. As for the feature - cognitive tool, the participant reported to pay low attention to its appearances in both games. Also, she reported to have a low curiosity when the explanations were provided by the tool after each task in both games was finished. As for the feature - content, the participant reported to feel a high coherency in the storyline and to be able to see the ERM knowledge embedded in the tasks in both games. She also reported that she felt curious about what the tasks in both games would be like and how the story in both games would end. However, she did not feel curious in gaining knowledge from the explanations given in both games.

| **ILE Features** | **Direct Effects** | | **Meta Effects** | | **Side Effects** |
|---|---|---|---|---|---|
| | + | - | + | - | + |
| Imagery | Attracted to the colourful scenes and the immediate appearance of the cognitive tool in both games | A low attention paid to the 'First Task' and the 'Second Task' scenes in both games as the participant reported not to be able to spot anything interesting in the scenes | | Seemed to have a low curiosity when playing both games in general | |
| Feedback | A high attention paid to the feedback given during both tasks of the first game and during the first task of the second game | A low attention paid to the feedback given during the second task of the second game | | A low curiosity about what feedback would be given during the tasks in both games | |
| Cognitive Tool | | A low attention paid to the cognitive tool whenever it appeared in both games | | A low curiosity towards the explanations given by the tool in both games | |
| Content | Felt a high coherency in the storyline of the game; Able to see the database knowledge embedded in the tasks in both games | | Curious about how the story would end in the first game; Curious about what the tasks in both games would be like | Seemed not to feel curious in gaining knowledge from the explanations given in both games | |
| Instructional goals | Likely to feel interested in learning databases at the start of the second game, but the feeling seemed to be faded away after progressing through the game | Seemed not to have an intention in learning nor having fun from the start of the first game and the game was not able to develop these feelings; Seemed to have a low feeling of fun from the start of the second game | | | |

Sources: Post-questionnaire, retrospective self-report, observational notes and semi-structured interview

Table 7.12: Effects matrix of ILE features of case study 6

After playing the first game, the participant reported that she did not enjoy playing the game and was not happy to learn from it. She made some comments concerning the characteristics of the game that the tasks in the game were quite easy and the characters in the game were all excessively good; the villains need to be not very nice. However, she did not mention anything regarding the ERM concepts embedded in the tasks which are different from the other two non-motivated cases – case study 4 and case study 5. When the participant finished playing the second game, she reported that she was still not happy to either play or learn from the game. She made some further comments that the story and the tasks of the second game should be changed as they were the same as those of the first game. Also, the game should contain hidden features which allow the player to explore. Again, the participant did not mention anything regarding the ERM knowledge embedded in the second game.

## 7.4.3 Representations for Explaining the Motivation of Case Study 6

### 7.4.3.1 Explanatory Effects Matrix

Tables 7.13 and 7.14 display the overall picture of the relationships among trait characteristics, ILE features and state characteristic in the first and the second play, respectively. Similar to case study 1, the explanation of the table was also created.

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state) | | Longer-Run Consequences (overall-state perspective) | |
|---|---|---|---|---|---|---|
| | | | Direct Effects | Meta Effects | Initial States | Consecutive States |
| | Instructional goal: Support Learning | | **Long-Term Relevance:** Seemed not to be interested in gaining the database knowledge from the start of the game; Was not happy to learn from playing the game | **Cognitive curiosity:** Generally a low level of curiosity as progressing through the game except when the tasks in the game were mentioned **Effort:** A high level of effort used in playing the game in general except when the explanations about the knowledge embedded in the task were given **Confidence:** A high confidence in the early scenes; a low confidence from when the tasks in the game were mentioned to the end | **Long-Term Relevance:** L | **Cognitive curiosity:** L **Effort:** H **Confidence:** H |
| | Instructional goal: Provide Fun | | **Long-Term Relevance:** Seemed not to be interested in playing the game after having a glimpse of the story and all characters at the beginning of the game; Was not happy to play the game | | **Long-Term Relevance:** L | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Long-Term Relevance:** Able to see the database knowledge embedded in the tasks of the game | | **Long-Term Relevance:** VH | |
| | Cognitive Tool | Can choose not to receive the explanations from Mushyman | **Attention:** Drew the attention of the participant by the immediate appearance of the tool, but not its explanation | | **Attention:** L | **Cognitive curiosity:** L/H/L **Effort:** L/H/L **Confidence:** L/H/L |
| Challenge | Feedback | Guided feedback | **Attention:** Attracted the participant's attention by telling her about the performance in doing the tasks | | **Attention:** H | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** Mostly caught the attention of the participant when playing the game except in the 'First Task' and the 'Second Task' scene where the participant reported not to be able to spot anything interesting | | **Attention:** H | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Felt a high coherency in the storyline of the game; Able to see the database knowledge embedded in the tasks of the game | | **Long-Term Relevance:** VH | **Cognitive curiosity:** L **Effort:** H **Confidence:** H |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.13: Explanatory effects matrix of case study 6 (first play)

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state) | | Longer-Run Consequences (overall-state perspective) | |
|---|---|---|---|---|---|---|
| | | | Direct Effects | Meta Effects | Initial States | Consecutive States |
| | Instructional goal: Support Learning | | **Long-Term Relevance:** Seemed to feel interested to know what database knowledge could be learned at the start of the second game; Was not happy to learn from playing the game | **Cognitive curiosity:** Generally a low level of curiosity as progressing through the game except when the tasks in the game were mentioned **Effort:** A high level of effort used in playing the game in general except when the same activity as in the first game was given (collecting the mushrooms in order to move on) and when the explanations about the knowledge embedded in the task were given **Confidence:** A low confidence at the start of the second game; A higher confidence when the participant was asked to complete the same activity as in the first game (collecting the mushrooms in order to move on); a low confidence from when the tasks in the game were mentioned to the end | **Long-Term Relevance:** L | **Cognitive curiosity:** L **Effort:** H **Confidence:** H |
| | Instructional goal: Provide Fun | | **Long-Term Relevance:** Seemed not to be interested in playing the game after having a glimpse of the story and all characters at the start of the game; Was not happy to play the game | | **Long-Term Relevance:** L | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Long-Term Relevance:** Able to see the database knowledge embedded in the tasks of the game | | **Long-Term Relevance:** VH | |
| | Cognitive Tool | Can choose not to receive the explanations from Mushyman | **Attention:** Drew the attention of the participant by the immediate appearance of the tool, but not its explanation | | **Attention:** L | **Cognitive curiosity:** L/H/L **Effort:** L/H/L **Confidence:** L/H/L |
| Challenge | Feedback | Guided feedback | **Attention:** Paid high attention to the feedback given during the first task, but a low level of attention was reported when the feedback was given during the second task | | **Attention:** H | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** Mostly caught the attention of the participant when playing the game except in the 'First Task' and the 'Second Task' scene where the participant reported not to be able to spot anything interesting (similar to when the participant played the first game) | | **Attention:** H | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Still felt a high coherency in the storyline of the game; Able to see the database knowledge embedded in the tasks of the game | | **Long-Term Relevance:** VH | **Cognitive curiosity:** L **Effort:** H **Confidence:** H |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.14: Explanatory effects matrix of case study 6 (second play)

According to the tables, the participant reported that in a learning environment she preferred to have a high control and to be independent when learning. However, she did not like challenging situations. As a result, she was assigned by MoRes to play Alex's Adventure 4.0 which was considered to be the appropriate version for this type of trait characteristics (high-control, low-challenge and high-independence type). In this version the participant was allowed to have control over the features: content and cognitive tool. That is, she could choose which storehouse/wagon she preferred to start working with when doing the tasks in the game (content) and she could choose whether to receive the explanation from Mushyman after finishing each task (cognitive tool). In addition, if she made a mistake when performing the tasks, she would receive the direct feedback informing explicitly about what went wrong and what was supposed to be right. However, since the participant reported not to be motivated to learn at the end of the game, she was asked to play the adjusted version of Alex's Adventure 4.0 (Alex's Adventure 8.0) afterwards. This version of the game is similar to the original version except that some changes were made to the imagery used in the game (see section 5.3.1.4 for more details on the changes).

Based on the data (see Figures 7.7 and 7.8 for the plot of relevance which was measured against two instructional goals), the participant seemed not to have the goal in learning from the beginning of the first game and the game was not able to influence the development of this goal since she reported at the end of the game that she was not motivated to learn through the game ILE. At the start of the second game the participant reported to feel interested in the database knowledge embedded in the game. However, as she progressed through the game the feeling was likely to fade away. As for the feeling of fun, the participant did not seem to have fun when playing both games and generally, she reported to have the low feeling of fun throughout the games. As a result, it was considered that there seems to be only one type of relevance for this case (different from case study 1): long-term relevance (the relevance state which occurred from the start of the interaction), and it seems that the instructional goals were not relevant to the participant's goals in long-term since the participant reported not to have a feeling to learn and did not seem to feel fun from the start to the end of the games. This demonstrates that the goals of the game ILE were not matched well with the goals of the participant. In other words the participant might have the other goals other than the goals in learning and in having fun with the game or she might have different expectations towards the game ILE (e.g. she might expect to play the high quality game similar to the commercial games in the market.). Based on the explanation so far, it was considered that the instructional goals, which were set when designing the game environment, could have an effect on the relevance state of the participant directly.

Content (the story and the knowledge embedded in the game) is another feature that was considered to have a direct effect on the long-term relevance of the participant. According to the participant's report, she felt a high coherency in the storyline of both games and she could see the ERM knowledge embedded in the task. However, the story of the games was not able to satisfy her feeling of fun and could not make her wanted to learn by playing the games.

On the other hand, cognitive tool, feedback and imagery are the features which were considered to have a direct effect on the attention state of the participant instead. According to the plots of attention which was measured against these features in the first and the second play (see Figures 7.5 and 7.6), the participant was likely to be attracted to the use of colourful imagery in both games and the funny look of the character – Mushyman; the appearances of the cognitive tool in both games could draw the attention of the participant, but, she reported not to feel attentive to its explanations regarding the ERM knowledge embedded in the games. Furthermore, a lower level of attention was reported in the scenes where the participant reported not to spot any interesting object (the ‘First Task’ and the ‘Second Task’ scenes in both games). As for the feature – feedback, the participant reported to pay high attention when it was given during both tasks of the first game and during the first task of the second game; however, she reported to pay low attention when it was given during the second task of the second game.

Apart from causing the direct effect as explained earlier, the features were also considered to cause the meta effects and three motivational states (cognitive curiosity, effort and confidence) were considered to be the meta effects caused by these features. As shown in the plots of cognitive curiosity, effort and confidence in the first and the second play (see Figures 7.9 and 7.10), the values of cognitive curiosity generally were reported to be low in both games except in the scenes that contained the mysterious elements where the participant reported to feel highly curious (such as the ‘Meet Dr de Ville’ scene in which the tasks in the game were mentioned for the first time and the ‘Back to Emma’ scene in which the end of the story was revealed). Furthermore, it was noticed that the value of cognitive curiosity, to some degree, related to the value of attention and of long-term relevance as can be seen from the plot of these motivational states, there are some similarities in some plot points; for example, in the ‘Opening & Invitation’ scene, the value of cognitive curiosity is the same as the value of attention and of relevance and in the ‘Meet Dr de Ville’ scene, the value of cognitive curiosity is the same as that of attention towards the imagery. According to the literature explained in section 4.2.3, cognitive curiosity seems to be the state that occurs after the participant’s attention is gained and his/her goal in learning is established. Based on the evidence and the literature, it was considered that before the cognitive curiosity state of the participant was affected, to some extent, she was first attracted to the game or found that the game was relevant to her needs at some points during interaction and thus, cognitive curiosity is the motivational state that is likely to be affected after attention and long-term relevance.

As also can be seen from Figures 7.9 and 7.10, the effort used in playing the first game was reported to be high in general except in the scenes in which the explanations about the knowledge embedded in the task were given (the ‘Meet Mushyman #1’ scene and the ‘Meet Mushyman #2’ scene). Similarly, the level of effort used in playing the second game generally was reported to be high except in the scene (‘In the Forest’ scene) where the participant was asked to do the same activity as in the first game (finding all hidden mushrooms) and in the scenes in which the explanations about the knowledge embedded in the tasks were given (the ‘Meet Mushyman #1’ scene and the ‘Meet Mushyman #2’ scene). Furthermore, from the figures it seems that the values of effort, to some extent, were influenced by the values of either attention or long-term relevance, or both (based on the literature described in section 4.2.3 and the similarities in some plot points of these motivational states) and hence, effort was considered to be the motivational states that was likely to be affected after attention and long-term relevance.

As for the confidence state of the participant, the graphs in Figures 7.9 and 7.10 show that the participant felt highly confident in the earlier scenes of the game (‘Opening & Invitation’ and ‘In the Forest’ scene); however, after these scenes, she reported that the game did not make her felt more confident. Two speculations were made in order to explain this incident. The first speculation is that the participant might clearly understand the ERM knowledge embedded in the task since she reported to have some background knowledge in database modelling and she could perform the tasks very well. Thus, she might feel highly confident when playing the game and felt that the game did not help strengthen her confidence level much. The second speculation is that the participant might have a difficulty in understanding the concepts of ERM in the tasks and the explanations might not help her much in clarifying the embedded knowledge which resulted in the report that the game did not make her felt more confident in doing the next task (if there was any). It was considered that the second speculation seems to be the case as it looked like the participant did not understand the database knowledge embedded in the game even though she could perform the tasks very well. The reasons for making this inference are:

- The participant reported to pay low attention to the explanations given by the cognitive tool in both games (similar to case study 5 who was still not motivated to learn after playing the second game).
- Even though the participant was not attracted to the cognitive tool in both games, she did not mention anything about what was wrong with it (different from case study 5).

- The participant did not mention anything about the database knowledge embedded in the games; the comments that she made about both versions of the game usually involve with the superficial issues such as the story, the graphics, etc. (which looked like she compared our games to the commercial games).

In addition, according to the observational notes, when the participant was asked by MoRes to play the adjusted version of the first game, she seemed to feel uncomfortable. She also reported that she did not feel like she was ready to play the second game. However, as she progressed through the second game, she reported that she had the same confidence level as when she played the first game (which might be because the participant perceived that the adjusted game was not changed much). It was considered that if the participant understood the ERM knowledge embedded in the game, some comments about how the game could be improved in the educational aspects were likely to be provided (as in case study 4). Furthermore, it was considered that before the confidence state of the participant was affected, to some extent, she was attracted to the game and tried to progress through the game (based on the literature described in section 4.2.3 and the similarities in some plot points of the motivational states: attention and effort). Thus, it was considered that confidence is the motivational state that was likely to be affected later.

#### 7.4.3.2 Case Dynamics Matrix

Since the participant played two versions of the game, eight tables of case dynamics matrix were created. Tables 7.15, 7.16, 7.17 and 7.18 display how the features of the first game cause changes in the values of the participant's motivational states whereas Tables 7.19, 7.20, 7.21 and 7.22 present the changes in the values of the participant's motivational states caused by the features of the second game.

As can be seen from Table 7.15 (column: Underlying Issues (as seen by us)), the participant paid low attention to the imagery used at the start of the first stage (#1 in 'The Prelude'); however, she reported to pay higher attention later in the stage (#2 and #3 in 'The Prelude'). Also, the participant did not seem to have the goal in learning at the beginning; nevertheless, she reported to have a suspicion that the tasks which were mentioned at the end of the stage might be relevant to learning database modelling. Furthermore, she reported to have a low feeling of fun at the beginning of the stage, but the feeling was reported to increase when the tasks in the game were first mentioned. As for the cognitive curiosity state, the participant reported to have a low level of curiosity at the beginning; however, she felt more curious when there was a mention about the tasks in the game. The participant reported to use a high level of effort when playing in this stage of the game and she also reported to feel highly confident; however, at the end of the stage she reported that the game did not seem to have any effect in increasing her confidence level. According to this, the strategies were specified in order to deal with these issues as can be seen from the column: How to Cope with. It was considered that the game could preserve/raise the level of attention by using more colourful graphics in the following scenes. The high feeling of fun could be sustained/increased by including more fun elements (e.g. surprise events or interactive activities) in the consecutive scenes. The interest towards the ERM knowledge could be maintained by presenting the knowledge in the subsequent scenes and the presentation of the knowledge was also supposed to be able to keep/raise the high level of cognitive curiosity and of effort through the next stage. Also, the game could consider increasing the level of confidence of the participant in the next stage.

| **ILE Features** | | **Motivational States** | | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | |
| G: Support Learning | | **Long-Term Relevance:**<br>L (#1 - #2)<br>VH (#3) | **Cognitive curiosity:**<br>L (#1 - #2)<br>H (#3)<br>**Effort:**<br>H (#1 - #3)<br>**Confidence:**<br>H (#1 - #2)<br>L (#3) | **For long-term relevance:**<br>- A low feeling of learning at the beginning of the stage (#1 - #2)<br>- Very high suspicions towards the task mentioned at the end of the stage that it might be relevant to database knowledge(#3)<br>- A low feeling of fun at the start of the stage (#1 - #2)<br>- A high feeling of fun at the end of the stage (#3)<br>**For attention:**<br>- A low attention towards imagery at the start of the stage (#1)<br>- A high attention later in the stage (#2 - #3)<br>**For cognitive curiosity:**<br>- A low value at the beginning of the stage (#1 - #2)<br>- A high value at the end of the stage (#3)<br>**For effort:**<br>- A high value throughout the stage (#1 - #3)<br>**For confidence:**<br>- A high confidence at the beginning of the stage (#1 - #2)<br>- A low confidence at the end of the stage (#3) | **For long-term relevance:**<br>- Sustained the feeling of learning and maintained/increased the feeling of fun by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>**For attention:**<br>- Preserved/raised the level of attention by using more colourful graphics in the following scenes<br>**For cognitive curiosity:**<br>- Kept/increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Sustained/raised the level of effort by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide fun | | **Long-Term Relevance:**<br>L (#1)<br>VL (#2)<br>H (#3) | | | |
| Content | | **Long-Term Relevance:**<br>L (#1)<br>H (#2)<br>VH (#3) | | | |
| | Cognitive Tool | **Attention:**<br>AS (#1 - #3) | | | |
| Imagery | | **Attention:**<br>L (#1)<br>H (#2 - #3) | | | |
| | Feedback | **Attention:**<br>AS (#1 - #3) | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.15: Case dynamics matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 6 (first play)

Table 7.16 (column: How Issues in Matrix 1 Resolved) shows how the strategies explained in the previous matrix could be implemented in the game environment and thus, our game prototype was unfolded in order to serve this purpose. The first task was given to the participant and after the task was finished the explanation about the knowledge embedded in the task was provided. The revelation of the task and the explanation aimed at sustaining/increasing the feeling of fun and maintaining the participant's interest in the ERM knowledge. Also, it aimed at keeping/raising the high level of cognitive curiosity and of effort used from the previous stage. The feedback relating to the participant's performance was also given during the task. A short praise was given for every correct choice and a guided feedback was given for every wrong choice. The use of feedback aimed at increasing the confidence of the participant when playing in this stage of the game. Furthermore, the colourful scenes and the funny look of the cognitive tool were used to raise her attention. As a result of this implementation, the values of the participant's motivational states were reported to change as shown in the column: Underlying Issues (as seen by us). The participant reported to be able to see the knowledge embedded in the task, but was not happy to learn from the explicit explanation given after the task was finished; also, she did not enjoy doing the task. However, she reported to be attracted by the imagery used in this stage of the game and paid high attention to the feedback given during the task. As for cognitive curiosity, effort and confidence, the participant reported to have a low level of curiosity throughout the stage, but she reported to use a high effort when doing the task in the game; however, a low effort was reported to be used when the explanation was given. Also, she reported that playing the game in this stage did not make her felt more confident to move on to the next task. Based on these issues, the strategies were specified as appeared in the column: How to Cope with. The second task was considered to be given to increase the feeling to learn and to raise her feeling of fun. The task would be slightly different from the previous task, but not too difficult in order to raise the level of cognitive curiosity, of effort and of confidence in the next stage. In addition, the imagery used in the second task was changed to increase the attention level as it was reported to be low at the end of this stage.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">How Issues in Matrix 1 Resolved:</th><th rowspan="2">Underlying Issues (as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>L (#5)</td><td rowspan="6">Cognitive curiosity:<br>L (#4 - #5)<br>Effort:<br>H (#4)<br>L (#5)<br>Confidence:<br>L (#4 - #5)</td><td rowspan="6">For long-term relevance:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For attention:<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>For cognitive curiosity:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For effort:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For confidence:<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4)</td><td rowspan="6">For long-term relevance:<br>- Able to see the database knowledge embedded in the first task (#4)<br>- Was not happy to learn from the explicit explanation about the knowledge embedded in the task (#5)<br>(A low feeling of learning at the end of the stage)<br>- A low feeling of fun throughout the stage<br>(Decreasing feeling of fun in this stage)<br>For attention:<br>- A high attention towards the imagery throughout the stage<br>- A high attention towards feedback when it was given during the task (#4)<br>-A low attention towards the cognitive tool (#5)<br>(Dropping value at the end of the stage)<br>For cognitive curiosity:<br>- A low level of cognitive curiosity throughout the stage<br>(Decreasing value throughout the stage)<br>For effort:<br>- Varying level of effort throughout the stage (from the level of high to the level of low)<br>(Decreasing value at the end of the stage)<br>For confidence:<br>- A low level of confidence throughout the stage<br>(Remaining low level of confidence)</td><td rowspan="6">For long-term relevance:<br>- Increased the feelings of long-term relevance by giving another task to do<br>For attention:<br>- Raised the level of attention by making use of the feature: imagery<br>For cognitive curiosity:<br>- Increased the level of curiosity by giving another task which should be slightly different from the first task<br>For effort:<br>- Raised the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>For confidence:<br>- Increased the level of confidence by giving another task which should not be too hard compared to the first task</td></tr>
<tr><td>G: Provide Fun</td><td></td><td>Long-Term Relevance:<br>VL (#4)<br>L (#5)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H (#4 - #5)</td></tr>
<tr><td>Cognitive Tool (#5)</td><td>Cognitive Tool (#4)</td><td>Attention:<br>AS (#4)<br>L (#5)</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>H (#4 - #5)</td></tr>
<tr><td>Feedback (#4)</td><td>Feedback (#5)</td><td>Attention:<br>H (#4)<br>AS (#5)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.16: Case dynamics matrix 2: 'The First Task' (snapshot 4 – snapshot 5) of case study 6 (first play)

Table 7.17 (column: How Issues in Matrix 2 Resolved) shows how the strategies described earlier could be implemented in the game environment by taking our game prototype as an example. The participant was presented with the second task and the explanation about the knowledge in the task. The task aimed at increasing her feeling to learn by playing the game; it also aimed at raising her feeling of fun, her cognitive curiosity and the level of effort used in playing the game. Similar to the first task, the participant was given the feedback concerning her performance when doing the task in order to increase the confidence level. The theme of the scene was also changed to raise her attention. The values of the participant’s motivational states were changed because of this implementation as shown in the column: Underlying Issues (as seen by us). The participant still reported to have a low feeling to learn from the game. Her feeling of fun was also reported to be low and she was not attracted to the imagery used at the beginning of the stage. However, the funny look of the cognitive tool was reported to be able to draw her attention, but she reported not to pay much attention to its explanation. As for feedback, the participant reported to pay high attention to this feature when it was given during the task. As for cognitive curiosity, effort and confidence, the participant reported to have the same feelings as in the previous stage. A low curiosity was reported throughout this stage. A high effort was reported to be used when doing the task whereas a low effort was reported when the explanation was given. Again, the participant reported that playing the game in this stage did not make her felt more confident to move on to the next task (if there was any). The strategies were specified to deal with these issues as appeared in the column: How to Cope with. It was considered that the game should increase the participant’s feeling to learn and her feeling of fun. Also, the level of cognitive curiosity, of effort and of confidence should be raised in the next stage. To achieve this, the feature: content, would be exploited. Two choices were considered in making use of this feature: offering a new task or continuing the story. It was considered that continuing the story seems to be the more appropriate choice (see section 7.3.3.2 for the same explanation as given for case study 1). As a result of this choice, it seems that the feeling to learn of the participant in the next stage might not be affected since no more tasks would be given to the participant. In addition, the feature: imagery would be exploited in order to increase the attention of the participant.

| ILE Features | | Motivational States | | How Issues in Matrix 2 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#6)<br>L (#7) | **Cognitive curiosity:**<br>L (#6 - #7)<br>**Effort:**<br>H (#6)<br>L (#7)<br>**Confidence:**<br>L (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- Able to see the knowledge embedded in the second task (#6)<br>- Was not happy to learn from the explanation at the end of the stage(#7)<br>(Remaining low feeling of learning)<br>- A low feeling of fun throughout the stage<br>(Remaining low feeling of fun)<br>**For attention:**<br>- A low attention towards the imagery at the start (#6); A high attention at the end (#7)<br>- A high attention towards feedback given during the task (#6)<br>-A low attention towards the cognitive tool (#7)<br>(Remaining low level of attention at the end)<br>**For cognitive curiosity:**<br>- A low level of cognitive curiosity throughout the stage<br>(Remaining low level of curiosity at the end)<br>**For effort:**<br>- Varying level of effort throughout the stage (from the level of high to the level of low)<br>(The same level of effort used as in the previous stage)<br>**For confidence:**<br>- A low level of confidence throughout the stage<br>(Remaining low level of confidence) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Raised the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>VL (#6)<br>L (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>H (#6 - #7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>L (#7) | | | | |
| Imagery | | **Attention:**<br>L (#6)<br>H (#7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>H (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.17: Case dynamics matrix 3: 'The Second Task' (snapshot 6 – snapshot 7) of case study 6 (first play)

Table 7.18 (column: How Issues in Matrix 3 Resolved) shows how the strategies described earlier could be implemented in the game environment (considering our game prototype as an example). The ending of the story was revealed to increase the participant's feeling of fun and the level of her cognitive curiosity as they were reported to be low at the end of the previous stage. Also, the colourful scene was presented once again to draw the attention of the participant and to raise the level of effort and of confidence in this stage. As a result of this implementation, the participant reported to be attracted by the colourful imagery used in this stage and felt curious about how the story would end; however, she still reported to have a low feeling of fun in this stage and the game did not have any effect on her confidence level. After the ending was revealed, the participant reported to feel a high coherency in the storyline and she reported to use a high effort when playing the game in general. Similar to case study 4 and case study 5, when she was asked to report her overall motivation at the end of the game, she reported not to be motivated to neither play with the game nor learn from it (unsatisfying outcome). Thus, she was asked to play the adjusted game.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">How Issues in Matrix 3 Resolved:</th><th rowspan="2">Underlying Issues (as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>L</td><td rowspan="6">Cognitive curiosity:<br>H<br>Effort:<br>H<br>Confidence:<br>L</td><td rowspan="6">For long-term relevance:<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>For attention:<br>- Presented the colourful scene - Emma's house – once again<br>For cognitive curiosity:<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>For effort:<br>- Involved an action from the participant in controlling the main character – Alex<br>For confidence:<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)</td><td rowspan="6">For long-term relevance:<br>- A low feeling of learning in the last stage (Remaining low feeling of learning from the previous stage)<br>- The low feeling of fun in the last stage (Remaining low feeling of fun from the previous stage)<br>For attention:<br>- A high attention towards the imagery used in this stage (Increasing attention level from the previous stage)<br>For cognitive curiosity:<br>- A high level of curiosity in this stage (Increasing level of curiosity from the previous stage)<br>For effort:<br>- A high level of effort used in this stage (Increasing level of effort used from the previous stage)<br>For confidence:<br>- A low level of confidence in this stage (Remaining low level of confidence from the previous stage)</td><td rowspan="6">- Resulted in unsatisfying outcome (the participant was finally not motivated to learn with the game environment)<br>- Assigned the participant to play with the adjusted version of this game</td></tr>
<tr><td>G: Provide Fun</td><td></td><td>Long-Term Relevance:<br>L</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H</td></tr>
<tr><td></td><td>Cognitive Tool</td><td>Attention:<br>AS</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>H</td></tr>
<tr><td></td><td>Feedback</td><td>Attention:<br>AS</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.18: Case dynamics matrix 4: 'The Finale' (snapshot 8) of case study 6 (first play)

Tables 7.19, 7.20, 7.21 and 7.22 display how the features of the adjusted game cause changes in the values of the participant's motivational states. In the adjusted game the imagery used in 'The First Task' and 'The Second Task' stage was changed evidently (more colourful graphics were used and the process of moving the chests to the storehouses/wagons was more visible). However, these changes did not seem to have a strong effect on the motivational states of the participant. She still reported to have a low feeling to learn and a low feeling of fun. The values of the other motivational states were reported to be similar to those in the first game. The participant reported to have a low curiosity, but, to use a high effort when playing the game in general. As for her confidence, she seemed to feel low confident at the start, but as she progressed through the game, she reported that the game did not have any effect on her confidence. When the participant was asked to report her overall motivation at the end, she still reported not to be motivated to neither play nor learn with the adjusted version of the game.

| ILE Features | | Motivational States | | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#1, #3)<br>L (#2) | **Cognitive curiosity:**<br>L (#1 - #2)<br>H (#3)<br>**Effort:**<br>H (#1, #3)<br>L (#2)<br>**Confidence:**<br>L (#1, #3)<br>H (#2) | **For long-term relevance:**<br>- A high interest in the database knowledge embedded in the game at the start of the stage (#1); High suspicions towards the task mentioned at the end of the stage that it might be relevant to database knowledge(#3)<br>- A low feeling of fun earlier in the stage (#1 - #2)<br>- A high feeling of fun at the end of the stage (#3)<br>**For attention:**<br>- A low attention towards imagery at the start of the stage (#1)<br>- A high attention later in the stage (#2 - #3)<br>**For cognitive curiosity:**<br>- A low value at the beginning of the stage (#1 - #2)<br>- A high value at the end of the stage (#3)<br>**For effort:**<br>- A high effort used at the start and at the end of the stage (#1, #3)<br>- A low effort used at the middle of the stage where the same activity as in the first game was presented (#2)<br>**For confidence:**<br>- A low confidence at the beginning and at the end of the stage (#1, #3)<br>- A high level of confidence at the middle of the stage (#2) | **For long-term relevance:**<br>Sustained/Increased the feeling of learning and the feeling of fun by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>**For attention:**<br>- Maintained/raised the level of attention by using more colourful graphics in the following scenes<br>**For cognitive curiosity:**<br>- Preserved/increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept/raised the level of effort by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide fun | | **Long-Term Relevance:**<br>L (#1 - #2)<br>H (#3) | | | |
| Content | | **Long-Term Relevance:**<br>H (#1 - #3) | | | |
| | Cognitive Tool | **Attention:**<br>AS (#1 - #3) | | | |
| Imagery | | **Attention:**<br>L (#1)<br>H (#2 - #3) | | | |
| | Feedback | **Attention:**<br>AS (#1 - #3) | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.19: Case dynamics matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 6 (second play)

| **ILE Features** | | **Motivational States** | | **How Issues in Matrix 1 Resolved:** | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#4)<br>L (#5) | **Cognitive curiosity:**<br>L (#4 - #5)<br>**Effort:**<br>H (#4)<br>L (#5)<br>**Confidence:**<br>L (#4 - #5) | **For long-term relevance:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For attention:**<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>**For cognitive curiosity:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For effort:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4) | **For long-term relevance:**<br>- Able to see the database knowledge embedded in the first task (#4)<br>- Was not happy to learn from the explicit explanation about the knowledge embedded in the task (#5)<br>(A low feeling of learning at the end of the stage)<br>- A low feeling of fun throughout the stage<br>(Decreasing feeling of fun in this stage)<br>**For attention:**<br>- Varying level of attention throughout the stage (from the level of low to the level of high)<br>- A high attention towards feedback when it was given during the task (#4)<br>- A low attention towards the cognitive tool (#5)<br>(Dropping value at the end of the stage)<br>**For cognitive curiosity:**<br>- A low level of cognitive curiosity throughout the stage<br>(Decreasing value throughout the stage)<br>**For effort:**<br>- Varying level of effort throughout the stage (from the level of high to the level of low)<br>(Decreasing value at the end of the stage)<br>**For confidence:**<br>- A low level of confidence throughout the stage<br>(Remaining low level of confidence) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by giving another task to do<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by giving another task which should be slightly different from the first task<br>**For effort:**<br>- Raised the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>**For confidence:**<br>- Increased the level of confidence by giving another task which should not be too hard compared to the first task |
| G: Provide Fun | | **Long-Term Relevance:**<br>VL (#4)<br>L (#5) | | | | |
| Content | | **Long-Term Relevance:**<br>H (#4 - #5) | | | | |
| Cognitive Tool (#5) | Cognitive Tool (#4) | **Attention:**<br>AS (#4)<br>L (#5) | | | | |
| Imagery | | **Attention:**<br>L (#4)<br>H (#5) | | | | |
| Feedback (#4) | Feedback (#5) | **Attention:**<br>H (#4)<br>AS (#5) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.20: Case dynamics matrix 2: ‘The First Task’ (snapshot 4 – snapshot 5) of case study 6 (second play)

| **ILE Features** | | **Motivational States** | | **How Issues in Matrix 2 Resolved:** | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#6)<br>L (#7) | **Cognitive curiosity:**<br>L (#6 - #7)<br>**Effort:**<br>H (#6)<br>L (#7)<br>**Confidence:**<br>L (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- Able to see the database knowledge embedded in the second task (#6)<br>- Was not happy to learn from the explanation at the end of the stage (#7)<br>(Remaining low feeling of learning)<br>- A low feeling of fun throughout the stage<br>(Remaining low feeling of fun)<br>**For attention:**<br>- Varying level of attention throughout the stage (from the level of low to the level of high)<br>- A low attention towards feedback when it was given during the task (#6)<br>- A low attention towards the cognitive tool (#7)<br>(Remaining low level of attention at the end)<br>**For cognitive curiosity:**<br>- A low level of cognitive curiosity throughout the stage<br>(Remaining low level of curiosity at the end)<br>**For effort:**<br>- Varying level of effort throughout the stage (from the level of high to the level of low)<br>(The same level of effort used as in the previous stage)<br>**For confidence:**<br>- A low level of confidence throughout the stage<br>(Remaining low level of confidence) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Raised the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>VL (#6)<br>L (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>H (#6 - #7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>L (#7) | | | | |
| Imagery | | **Attention:**<br>L (#6)<br>H (#7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>L (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.21: Case dynamics matrix 3: ‘The Second Task’ (snapshot 6 – snapshot 7) of case study 6 (second play)

| ILE Features | | Motivational States | | How Issues in Matrix 3 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>L | **Cognitive curiosity:**<br>L<br>**Effort:**<br>H<br>**Confidence:**<br>L | **For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene - Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For long-term relevance:**<br>- A low feeling of learning in the last stage (Remaining low feeling of learning from the previous stage)<br>- A low feeling of fun in the last stage (Remaining low feeling of fun from the previous stage)<br>**For attention:**<br>- A high attention towards the imagery used in this stage (Increasing attention level from the previous stage)<br>**For cognitive curiosity:**<br>- A low level of curiosity in this stage (Remaining low level of curiosity from the previous stage)<br>**For effort:**<br>- A high level of effort used in this stage (Increasing level of effort used from the previous stage)<br>**For confidence:**<br>- A low level of confidence in this stage (Remaining low level of confidence from the previous stage) | - Resulted in unsatisfying outcome (the participant was finally not motivated to learn with the game environment) |
| G: Provide Fun | | **Long-Term Relevance:**<br>L | | | | |
| Content | | **Long-Term Relevance:**<br>H | | | | |
| | Cognitive Tool | **Attention:**<br>AS | | | | |
| Imagery | | **Attention:**<br>H | | | | |
| | Feedback | **Attention:**<br>AS | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table 7.22: Case dynamics matrix 4: 'The Finale' (snapshot 8) of case study 6 (second play)

### 7.4.3.3 The Revised Causal Model

Figure 7.11 shows the revised causal model of motivation of the case in a form of network. The motivational variables and the ILE features are represented by nodes whereas the relationships among them are represented using links. The details about the links can be explained in the same way as in case study 1 (see section 7.3.3.3 for the explanation).

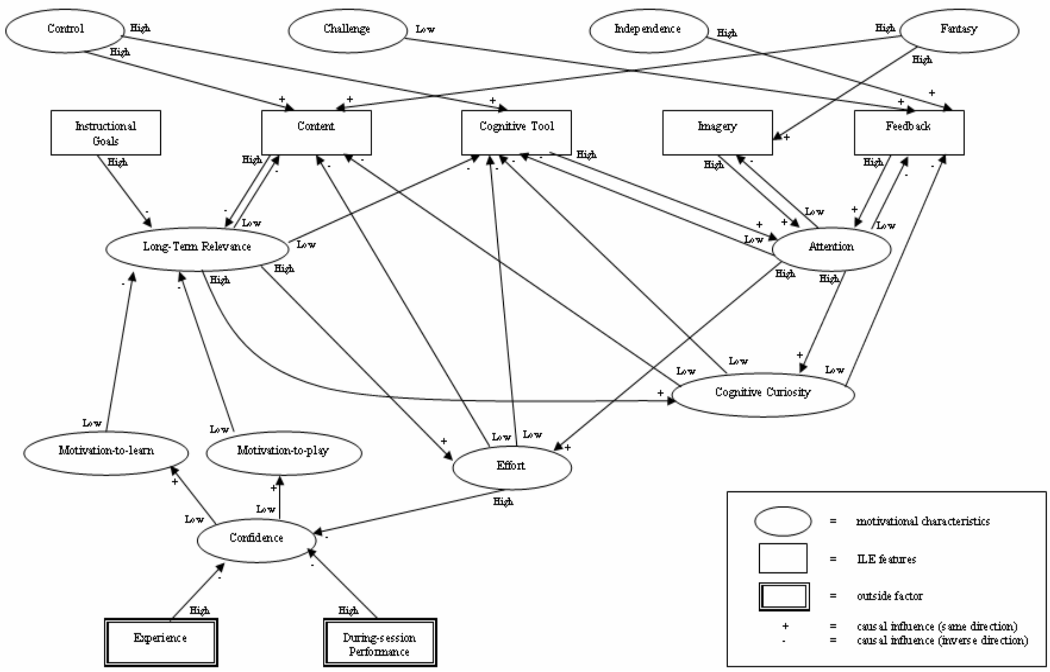


Figure 7.11: The revised causal model of motivation of case study 6

Also, similar to case study 1, the story of the model can be told as two related parts: the relationships between the trait characteristics of the participant and the features of the game ILE, and the relationships between the features of the game ILE and the state characteristics of the participant. In the first part the traits of the participant can be viewed as the independent variables whereas the features of the game ILE can be viewed as the dependent variables (or variables that vary according to the trait characteristics). The story of this part starts when the participant reported about her trait characteristics in a learning environment that she preferred to have control over the learning materials and she wanted to be independent when learning (she preferred not to get help from the tutor and would rather like to succeed by herself). However, she did not like high-challenging situations. Based on the report, MoRes assigned her to play Alex's Adventure 4.0 in which she could have control over some parts of the game content and the cognitive tool (which was also considered to be a part of the content as explained in case study 1). In addition, if the participant made a mistake when doing the tasks, she would be given the direct feedback that told her explicitly about what was supposed to be right. These design attempts at making the game better matched with the high-control, low-challenge and high-independent characteristics of the participant.

In the second part the features of the game and the states of the participant can be viewed as both the independent and the dependent variables (see explanation in case study 1). The story of this part begins when the participant started the interaction with the game environment.

As can be seen from the fluctuations of the graphs appeared in the plots of motivational states in both plays, (see Figures 7.5 and 7.6 for the plots of attention, Figures 7.7 and 7.8 for the plots of relevance and Figures 7.9 and 7.10 for the plots of cognitive curiosity, effort and confidence), the values of the participant's motivational states vary according to the scenes presented. Certainly, there are some similarities and some differences among these scenes; thus, some of them may contain the same features and some of them may consist of different features. Based on this fact, it was considered that the features included in a single scene could play an important role in the change in the value of the motivational states. That is, the features of the game environment could exert some influences on the motivational states of the participant.

According to the data (see Figures 7.5 and 7.6 for the plots of attention in the first and the second play), mostly, the use of imagery in the game ILE could attract the attention of the participant in both plays and thus, a link was drawn from the feature – imagery, to attention to represent this relationship. However, there were a few points in the first play where her attention was reported to be low. Hence, another link was drawn backward from attention to the feature – imagery, in order to show that this feature could be adjusted to raise the attention of the participant.

The appearance of the cognitive tool after the tasks were finished could catch the participant's attention; however, she reported not to be attracted to its explanations and did not make any further suggestions about the tool (e.g. how the tool could be improved). Based on this piece of evidence, a backward arrow was drawn from attention to the feature – cognitive tool, to demonstrate that the tool could be improved in order to raise the attention of the participant (e.g. the way in which the explanation was given could be more interactive).

Feedback given during the tasks was supposed to be able to draw the attention of the participant and it succeeded in doing so in the first game and in the first task of the second game; however, the participant reported to pay low attention when the feedback was given in the second task of the second game. According to this, an arrow was drawn from the feature – feedback, to attention to represent the relationship occurred in the first game and in the first task of the second game. Also, another arrow was drawn backward from attention to the feature – feedback, to show that this feature could be adjusted if the attention level of the participant was reported to be low.

According to the plots of relevance in the first and the second play (Figures 7.7 and 7.8), it seems that the participant did not have the goal in learning from the start of the first game and she started playing the game with a low feeling of fun. As she progressed through the game, she reported to feel a high coherency in the storyline, but the story was not interesting enough and it was not able to develop her feeling to learn. In the second game the participant reported to feel interested in the knowledge embedded in the game, but she still did not feel fun to start playing the game. As she progressed through the game, her interest in the knowledge seemed to fade away and her feeling of fun was reported to be continuously low. It was considered that the participant might have the different goals which were not matched with the goals of the game instruction (support learning and provide fun) and the content of the game was not succeeded in fulfilling her goals. Furthermore, the participant reported through the open-ended questions that the stories of both games were the same and the characters were all incredibly good. Also, the tasks in both games were not challenging to her. The participant preferred the more interesting story and the game that allows her to be able to explore more (e.g. have hidden features that players can find). However, she did not mention anything concerning how the game could be improved in the educational aspect. Based on this evidence, two arrows were drawn from the features: instructional goals and content, to long-term relevance to represent the effects caused by these features. Also, another two arrows were drawn backward from long-term relevance to the features: content and cognitive tool, to demonstrate the suggestions from the participant that the content could be adjusted. In addition, it was considered that adjusting the cognitive tool (e.g. the way in which the explanation was given) might be able to influence her feeling to learn from the game.

On the other hand, the other three motivational states: cognitive curiosity, effort and confidence, were considered to be affected after attention and relevance. As previously explained in the explanation of explanatory effects matrix (section 7.4.3.1), cognitive curiosity was the motivational state that was likely to be affected by attention and long-term relevance and the values of cognitive curiosity, to some extent, were considered to be driven by the values of either attention or long-term relevance, or both. Thus, two arrows were drawn from the motivational states: attention and long-term relevance, to cognitive curiosity to represent this relationship. However, the participant generally reported to have a low level of cognitive curiosity throughout the interactions with both games and she also reported to have a low level of curiosity when the explanations were given by the cognitive tool. Thus, it was considered that the content of the game and the cognitive tool could be adjusted in order to raise her cognitive curiosity; two arrows were drawn backward from cognitive curiosity to the features: content and cognitive tool. Furthermore, the participant reported that she was not curious about the content of the feedback given during the tasks even though it could gain her attention,. As a result, another arrow was drawn backward from cognitive curiosity to the feature – feedback, to show that this feature could also be adjusted as another way to raise the level of cognitive curiosity.

Similar to cognitive curiosity, effort was the motivational state that seemed to be affected after attention and long-term relevance and the values of effort, to some degree, were influenced by the values of either attention or long-term relevance, or both (see the explanation of explanatory effects matrix for the details). Therefore, two arrows were drawn from the motivational states: attention and long-term relevance, to effort to demonstrate this relationship. Also, the level of effort used in playing the games was reported to vary in different scenes. Generally, the participant reported to use a high effort when playing the game; however, a low effort was reported when she was asked to complete the repetitive activity (finding all hidden mushrooms in the 'In the Forest' scene) in the second game and when the explanations about the knowledge embedded in the tasks were given by the cognitive tool. Thus, it was considered that to increase the level of effort used, the content of the game could be adjusted by offering a new activity. Also, the cognitive tool could be changed to promote the use of higher effort (e.g. make the tool more interactive). To show this backward relationship, an arrow was drawn from effort to the features: content and cognitive tool.

As for confidence, it was also considered to be the motivational state that was affected later. Based on the explanation of explanatory effects matrix, the confidence state of the participant was considered to be affected when the participant was attracted to the game and tried to progress through it. However, as explained earlier, this participant seemed not to understand the ERM knowledge embedded in the game even though she could perform the tasks very well. As a result, she reported to have the 'low' value for most questions that ask whether the game make her felt more confident whereas the 'high' value was reported for most questions that relate to her effort. According to this, an arrow with a minus sign was drawn from effort to confidence to represent this inverse relationship (high effort – low confidence). Furthermore, for this case the outside factors (during-session performance and experience) did not seem to have any effect on her confidence level which is different from case study 1 (even though she reported to have some background in databases and could performed very well in both games, she still reported that she did not feel more confident when playing the game). Therefore, two arrows with a minus sign were drawn from these factors to confidence in order to show this inverse relationship.

At the end of the first game the participant reported not to feel motivated to both learn and play with the game. Hence, she was asked to play the second game (the adjusted version of the first game). At the end of the second game the participant still reported not to be motivated to both learn and play. It was considered that these data should be presented in the revised version of the model since it provides a better view towards the motivation of the case from both the first and the second play. This consideration leads to the augmentation of the motivation model of the case and the augmentation of the model was done based on the following rules: 1) in the context of educational game, there are two types of motivation: motivation to learn and motivation to play; hence, it was considered that motivation should be separated and thus, two nodes were added to the model: motivation to learn and motivation to play. 2) according to Keller's (1987) ARCS model, motivation is supposed to occur after a learner feels confident; in the first play, the case reported that when playing the game in general, it did not make her felt more confident and after the play, she reported not to feel motivated to both learn and play with the game; based on the ARCS and the result from the first play, two arrows were drawn from confidence to both types of motivation to represent the relationship between the confidence state and the motivation of the case; the arrow with a plus sign was used to represent the low confidence – low motivation-to-learn relationship and the low confidence – low motivation-to-play relationship; in the second play, the case also made the same report as when she played the first game; as a result, two arrows were drawn from motivation-to-learn to long-term relevance and from motivation-to-play to long-term relevance to show that in order to motivate the participant to learn from the game, the values of long-term relevance were supposed to be increased by either adjusting the tasks in the second game/the storyline of the second game (content) or changing the way in which the knowledge was presented explicitly in the game (cognitive tool) as previously mentioned in this section.

### 7.4.4 Summary of Case Study 6

This case was considered to be a special 'non-motivated' case since the participant was not motivated both to learn and to play after the first game. As a result, she was asked to play the second game which is the adjusted version of the first game and this version still did not succeed in motivating her.

The participant was asked to provide the trait characteristics in a learning environment and based on her report, she was assigned by MoRes to play Alex's Adventure 4.0 which was considered to be the appropriate version that suit with his traits. The trait characteristics of the case were shown in Table 7.9. Also, the participant was asked to report her motivational states during interactions with both games and her overall motivational states after finishing playing each game. The data regarding her motivational states during both interactions was presented using the event listing tables (Tables 7.10 and 7.11) and the plots of motivational states (Figure 7.5 – Figure 7.10). The effects matrix of ILE features (Table 7.12) was also used to describe the effects of the game features on the motivational states of the case in both plays. The causal mechanisms between the trait characteristics, the features of the game and the state characteristics in both plays were revealed using the explanatory effects matrices (Tables 7.13 and 7.14) and eight case dynamics matrices (Table 7.15 – Table 7.22). The revised causal model of motivation of the case was also created to present these causal mechanisms in a coherent picture (Figure 7.11).

Some major findings can be drawn from the study of this case as shown in the bullet points below.

- As for this case, it looks like she did not understand the ERM knowledge embedded in both games even though she could perform the tasks very well. The reasons for making such an inference are: (1) she reported to pay low attention to the explanations given by the cognitive tool in both games which is similar to case study 5 (case E01) who was still not motivated to learn after playing the second game (see Appendix F for further details on case study 5). (2) even though she was not attracted to the cognitive tool appeared in both games, she did not mention anything in the aspect of what was wrong with it which is different from case study 5 (case E01) who did mention about how the tool could be improved. (3) she did not mention anything regarding the ERM knowledge embedded in the game which is different from case study 4 (case E04) who reported not to be motivated to learn after playing the first game, but did mention about the knowledge embedded in the game in the aspect of how to present it in a more efficient way (see Appendix E for further details on case study 4). (4) the comments that she made concerning both versions of the game usually involve with the superficial issues such as the story, the graphics and so on which seems like she compared the game to the general commercial games. (5) based on the data from the self-report, the participant felt highly confident when she started playing the first game, but as she progressed through the game, she reported that the game did not make her felt more confident; however, when she was asked by MoRes to play the second game, she seemed to feel very uncomfortable and she also reported that she did not feel like she was ready to play this game and this seems to show her low confidence at the start of the second game; nevertheless, as she progressed through the second game, she reported that she had the same confidence level as when she played the first game (which might be cause she perceived that this version of the game was not changed much from the previous version).

- To develop the motivation in learning, the feelings of long-term relevance was supposed to be raised and the viable methods that probably work for this case is to adjust the content (e.g. the storyline and the tasks) and the cognitive tool (e.g. make it more interactive)
- To raise the attention level, the features: imagery, cognitive tool and feedback, could be adjusted (e.g. make some improvements to the graphics used in the game, changing the feedback style regarding the participant’s performance).
- To increase the cognitive curiosity, the features: feedback, cognitive tool and content, could be adjusted (e.g. make the story less predictable).
- To increase the level of effort used in the game ILE, the features: content and cognitive tool, could be adjusted (e.g. offering a more challenging tasks).
- Confidence was the motivational state that for this case its values were likely to change in the inverse direction compared to effort. Also, the outside factors (experience and during-session performance) did not seem to have an effect on the confidence state of the participant since the participant reported to have some backgrounds in databases and she could performed very well in both games, but she reported that the games did not make her felt more confident.

## 7.5 Summary

In this chapter we explained the preliminary issues relating to the analysis of all cases such as the data which was gathered from the field study and the data which was actually used in the analysis phase. The study of two cases were presented: case study 1 and case study 6 (the study of the other four cases: case study 2, case study 3, case study 4 and case study 5, can be found in Appendix C, Appendix D, Appendix E and Appendix F, respectively). The study of both cases was done in a similar fashion. We started with the background of the case. We, then, moved on to describe his/her motivation using three representations: event listing of motivational state, plots of motivational states and effects matrix of ILE features. After that, we explained the motivation of the case in the aspect of a causal mechanism between different features of the game ILE and different motivational states which were considered to constitute a learner's motivation. To explain this causal relationship, three representations were employed: explanatory effects matrix, case dynamics matrix and the revised causal model. We ended up our study of each case with the summary of the major findings.

It was considered that at this point we have a better insight into what was happening to the motivation of a single case. However, we got a feeling that there are some issues that can be drawn from the study of all cases. These issues will be discussed further in the next chapter.

# Chapter 8

# Discussion

## 8.1 Introduction

As mentioned in chapter 1, the aim of this research is to explore how learners are motivated when learning in the context of educational games. Six cases were studied and the results of the study of case study 1 and case study 6 were shown in the previous chapter whereas the results of the study of the other four cases (case study 2, case study 3, case study 4 and case study 5) were presented in Appendix C – Appendix F, respectively. All six cases were divided into two groups for the discussion purpose: ‘learners’ and ‘non-learners’. The ‘learners’ group refers to the participants who reported to be motivated to learn from playing our game prototype and three cases were categorised into this group: cases E02 (case study 1), E10 (case study 2) and E12 (case study 3). On the other hand, the ‘non-learners’ group refers to the participants who reported not to be motivated to learn from the game which resulted in another play with the adjusted version of the game. Three cases were categorised into this group: cases E04 (case study 4), E01 (case study 5) and E09 (case study 6). It was noticed that there are some similarities in the revised causal model among the cases who fall into the ‘learners’ group as well as the model of those who fall into the ‘non-learners’ group. As a result, two causal models were developed to demonstrate the motivational structure of the ‘learners’ and of the ‘non-learners’, respectively. However, one may find it is possible to combine the two models and feel that it does not make any difference whether the models are separately displayed or combined into a single model. However, it was considered that presenting the models separately provides a clearer picture of the similarities and the differences between the motivational structure of the ‘learners’ and the ‘non-learners’. Also, it is easier for us to create a model description. It was also noticed that some key points could be drawn from the analysis of the six cases. These key points are discussed in this chapter. Apart from the causal model developed for the ‘learners’ and the ‘non-learners’ and the key points, it was noticed that some condition-action rules could be obtained from the study of the six cases. As explained in chapter 5, the limitation of MoRes is that it was created on an ad hoc basis and thus, there might be some discrepancies between the values of the motivational states inferred by MoRes and those that were reported by students using paper-based research instruments. As a result, these condition-action rules were developed in the hope that it will be useful for the development of the computer program that implements the revised version of the motivation model.

We start the next section with the rules used for creating a causal model of motivation for each group of participant (the ‘learners’ and the ‘non-learners’ group). Then, we present the causal model of the ‘learners’ in section 8.3 followed by the causal model of the ‘non-learners’ in section 8.4. Some discussions regarding the models are made in section 8.5. In section 8.6 the key points are discussed. The condition-action rules are shown in section 8.7. We, then, conclude with a summary of the chapter.

## 8.2 The Rules for the Development of a Group Causal Model of Motivation

In chapter 4 we proposed the preliminary version of the causal model of motivation showing the relationship between the ILE features and a learner’s motivational characteristics as a roadmap for our exploratory work (Figure 4.1). After in-depth investigation of six case studies, we came up with the revised version of the model for each individual case (appears in chapter 7 and in Appendix C – Appendix F). In this chapter all those six models are combined and are reduced to two models: the causal model of motivation of the ‘learners’ which is explained in this section and the causal model of motivation of the ‘non-learners’ which will be explained in the next section.

It was considered that to create a single model for each group of participant, the rules used for combining the model created for each participant in the group should be specified. The revised motivation model of each group of participant was created based on the following rules:

1) Since the model consists of nodes which represent the different kinds of variables (motivational variables, ILE features and outside factors) and the motivation models of all participants in each group contain both the same and the different variables, when combining these models in order to develop a single model, both the same and the different nodes were included. The inclusion of the different node (short-term relevance in the motivation model of ‘learners’) was considered to be necessary as there may be other cases where this node exists in their motivational

structure even though in our analysis the node only exists for a single case (case E02 in the 'learners' group).

2) Since the model consists of links which represent the relationships among the motivational variables, the ILE features and the outside factors and the motivation models of all participants in each group contain both the same and the different links, when creating a single model, both the same and the different links were included (similar to what was done to the nodes explained earlier). Similar to what is explained above, the inclusion of the different links was considered to be important as it is possible that these links may also appear in the motivational structure of other cases which were not included in our analysis. However, one may question whether there is a possibility that the links may be contradictory (e.g. Is there a possibility that there is a motivational state which is not related to any node in the model? Is there a possibility that node A which relates to node B can also relate to node C? In order to answer these questions, it is important to emphasise that the revised motivation models presented in this research (Figures 8.1 and 8.2) were developed based on the qualitative approach and thus, the models demonstrate the relationship in the qualitative aspect and the models were considered to be better supported with numerical data. According to the literature described in chapter 4 (section 4.2.3) and the evidence obtained from the study, the links were considered to exist among different motivational states appearing in the model and based on a definition of motivation (Weiner, 1992) - motivation is caused by determinants which resulted in choices of thoughts and actions, it seems that for a single motivational state to occur and exist, there are factors that play an important role in this process. Based on this, it is unlikely that a single motivational state exists without having any relationship with other nodes in the model; however, as stated earlier, the model is best supported with statistical data in order to make use of it powerfully. As for the second question (Is there a possibility that node A which relates to node B can also relate to node C?), a similar answer can be given; the relationships among the nodes in the model are partly based on the literature and partly derived from the evidence and to strengthen the beliefs about these relationships, statistical data is required.

3) Since the preliminary motivation model contains the association texts describing the nature of the relationships (e.g. '$I^+$' which means the starting node can influence the target node directly by increasing its value and '$I^-$' which means the starting node can influence the target node directly by decreasing its value), in the revised motivation model created for each group of participants the association texts were

also used for the same purpose. However, the texts used in the revised model were changed slightly from those used in the preliminary model; the possible value of a specific motivational variable (‘High/Low’ for a trait variable and ‘High/Low/N/A’ for a state variable) and the symbols: ‘+’ and ‘-’, (the symbol ‘+’ means the value of the target node is changed in the same direction as the value of the starting node and the symbol ‘-’ means the value of the target node is changed in the inverse direction compared to the value of the starting node) were used instead of the texts: ‘$I^+$’ and ‘$I^-$’. The reasons behind these changes is to make the model less complicated (by using the symbols ‘+’ and ‘-’ instead of the texts: ‘$I^+$’ and ‘$I^-$’) and more practical (by specifying the initialisations of the model – the value of ‘High’ and of ‘Low’ (see section 5.3.1.4 for the details) and by describing the possible range[1] of motivational state data of the students – the value of ‘High’, ‘Low’ and ‘N/A’).

In sum, when developing a single model for each group of participant, the first rule is to include both the same and the different nodes appearing in a motivation model of each case. The second rule is to include both the same and the different links presenting in each model. The third rule is to use the association text (to show the possible value of a specific motivational variable) and the symbols ‘+’ and ‘-’ (to show the direction of change in the value of the target node compared to that of the starting node). An illustration of the implementation of these rules can be seen from the causal model of the ‘learners’ (Figure 8.1) and the causal model of the ‘non-learners’ (Figure 8.2).

## 8.3 The Causal Model of Motivation of ‘Learners’

The causal model of the ‘learners’ is shown in Figure 8.1. The story of the model can be told as two related parts.

The first part of the model shows the relationships between the trait characteristics of the ‘learners’ (independent variables) and the features of an ILE (dependent variables that vary according to the trait characteristics). These relationships are represented by links. As previously described in chapter 4, these links are based on a reading of the literature that a learner’s trait can influence the use of the ILE features, and thus, the ILE

[1] One may argue that the possible range of motivational state data seems to involve other values apart from these three values (‘High’, ‘Low’, ‘N/A’) such as the value of ‘Medium’. However, it was considered that there is an ambiguity in using the ‘Medium’ value as explained in section 5.3.1.4; also, it was considered that there might be a case where a student tended to report to have this value throughout the game interaction as he/she might feel reluctant to choose the value at the opposite end.

components should be able to adapt themselves according to the traits of the learner. Hence, for every individual case, the participant was asked to provide information about his/her trait characteristics in a learning environment through the computer program – MoRes, in which its function was to select the version of the game that was likely to suit him/her.

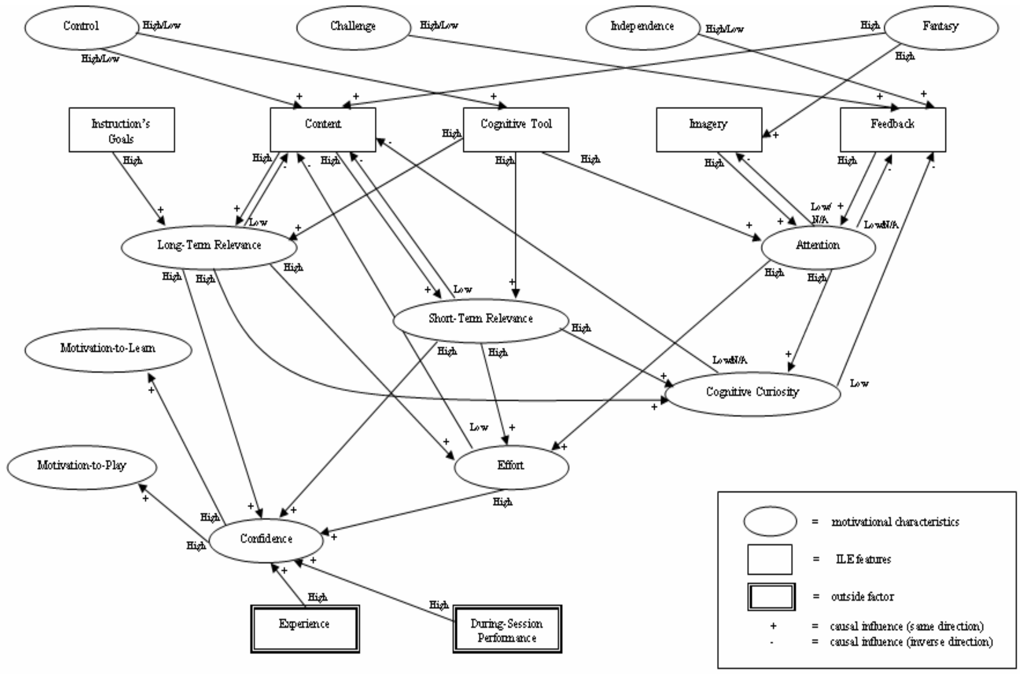


Figure 8.1: The revised causal model of motivation of 'Learners'

Looking at all cases in the 'learners' group, there are various combinations of the trait characteristics. For example, case E02 is a high-control, high-challenge and high-independence type. On the other hand, case E10 is a low-control, high-challenge and low-independence type while case E12 is a high-control, low-challenge and low-independence type. As a result of the different combinations of the trait characteristics, these three cases were assigned to play different versions of the game in which the features were tailored to be likely to suit their different characteristics. The links that appeared in this part of the model were similar to those of the preliminary version; however, the associated text was changed slightly to make the model less complicated and more practical as explained in rule 3). The text was changed from '$I^+$' (which means 'direct influence (increase)') and '$I^-$' (which means 'direct influence (decrease)') in the preliminary model to 'High/Low' in this revised model which refers to the value of a specific trait variable in our context. The symbol '+' was also used to demonstrate that the ILE features were supposed to be adjusted according to the specific value of each trait variable.

To illustrate this, taking the trait 'control' as an example, a 'learner' who prefers to have a high control in a learning situation (represented by the text 'High') was offered the learning environment in which he/she could have control over the features: content and cognitive tool (represented by the symbol '+' which refers to 'causal influence in the same direction as the starting node'). Similarly, a 'learner' who prefers to have low control (represented by the text 'Low') was offered the learning environment in which he/she could not have control over those two features (represented by the symbol '+' which refers to 'causal influence in the same direction as the starting node'). The relationships between the other trait characteristics and the ILE features can be explained in a similar way.

The second part of the model shows the relationships between the ILE features and the state characteristics of the 'learners'. The ILE features in this part can be viewed as both independent and dependent variables. They can be seen as the independent variables when they cause changes in the value of the related motivational states; on the other hand, they are the dependent variables when they need to be changed in order to raise the value of the related motivational states. Also, the state characteristics (motivational states) can be viewed as both independent and dependent variables. As mentioned in chapter 7, there are two types of motivational states: initial states (motivational states that are directly affected by the ILE features) and consecutive states (motivational states that are affected after the initial states). These motivational states can be seen as the independent variables when they are the initial states (attention, long-term relevance and short-term relevance) that cause a change in the value of the consecutive states (cognitive curiosity, effort and confidence).

The consecutive states, on the other hand, can be regarded as the dependent variables as their value change according to the value of the initial states. Similar to the trait characteristics – ILE features part, the relationships in this part of the model are represented by links. There are a few differences between this part of the model and that of the preliminary version. The first difference is the use of the associated text. 'High', 'Low' and 'N/A' are used instead of '$I^+$' and '$I^-$' as they are more practical and make the model less complicated (as already described in rule 3)). Also, they are suitable for describing the wide range of motivational state data of the 'learners'.

The second difference is the separation of the relevance state into two sub-states: long-term relevance and short-term relevance, and the inclusion of some outside factors (experience and during-session performance) which were considered to influence the value of the confidence state as explained in the analysis of each individual case.

The last difference is the order of the motivational states. In the preliminary model the motivational states were sketched in chronological order. However, in this revised version these motivational states were not put into order since according to the data, it is difficult to specify precisely which comes before which. Furthermore, we considered that it was hard to extract accurate data regarding the order of their motivational states since in doing so, it might trigger the cognitive overload which might affect their feelings (they might feel annoyed/upset which might decrease their intention in trying to think back and report their feelings when playing the game).

Looking across all cases in the 'learners' group, attention was the motivational state which was considered to be affected by three ILE features: cognitive tool, feedback and imagery. As can be seen from Figure H.1.1 (Appendix H), all three cases reported to feel attracted to the imagery used in the game (the graphs of their attention generally fall into the high-value area). However, some cases (case E10 and case E12) reported to pay low attention or were not able to report their attention level at some points in the game. These points were the points where a repetitive scene/similar setting was used. Also, as can be seen from Figure H.1.2 (Appendix H), all cases reported to feel attracted to the use of the cognitive tool in the game; however, some cases (case E02 and case E12) reported not to feel attracted to the feedback given in both tasks of the game as the style were the same. Based on this, it was considered that the imagery and the feedback used in the game could be adjusted in order to raise the value of attention; for example, according to some suggestions made by the participants, new scenes/settings might be introduced whereas the detailed feedback might be used instead of a short praise.

Relevance was the motivational state which was separated into two sub-states: long-term relevance[2] and short-term relevance[3]. We considered dividing relevance into two sub-states because there was a particular case (case E02) who seemed not to have any feeling to learn from the game in the first instance; however, the feeling was reported to develop later during interaction. In this revised model both types of relevance were considered to be affected by three ILE features: instructional goals, content and cognitive tool, whereas in the preliminary model relevance was sketched to be affected by two features – instructional goals and content. As can be seen from Figures H.2.1 and H.2.2 (Appendix H), two 'learners' (case E10 and case E12) were considered to have a high feeling that their goals were met throughout the interaction with the game (the

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[2] The long-term relevance state refers to the degree to which a learner's important personal needs are met from the beginning to the end of the instructional interaction.

[3] The short-term relevance refers to the degree to which a learner's new personal needs, which were developed during the instructional interaction, are met.

feeling of learning and the feeling of fun were satisfied). On the contrary, the other 'learner' (case E02) seemed not to have the feeling to learn at the beginning, but, he seemed to have a high intention to have fun with the game instead. However, his feeling to learn was reported to develop as he progressed through the serious part of the game (snapshot 4 – snapshot 7). According to this, it was considered that the features – instructional goals and content, could exert some influence on the long-term and short-term relevance as the needs of the participants seemed to match with the goals of the instruction throughout the interaction (instructional goals – long-term relevance) or during interaction (instructional goals – short-term relevance).

Also, from Figure H.2.3 (Appendix H), it was considered that the content of the game could fulfil the participant's goal in having fun with the game (content – long-term relevance) or even influenced the new goal – learning by playing the game (content – short-term relevance); as can be seen from the figure, the graphs representing their feelings that the content of the game was relevant to their goals mostly fall into the high-value area. Furthermore, when the cognitive tool was first presented in the game (Snapshot 5 in Figure H.2.1 (Appendix H)), the feelings that the game was relevant to the goal in learning in the long-term of two participants (case E10 and case E12) was driven to the highest level and the feelings that the game was relevant to the goal in learning in the short-term relevance was also reported to develop for the participant who did not seem to have these feelings from the beginning (case E02). According to this, it was considered that the cognitive tool could play an important role in the state of both long-term and short-term relevance. However, there were some points during interaction in which the values of long-term relevance and of short-term relevance were reported to drop to a low level and it was considered that the feature – content, could be adjusted in order to raise the values of these states. For instance, as suggested by the participants, the activity/ tasks in the game might offer the different levels of difficulty to make the game more challenging.

Cognitive curiosity is the motivational state which was considered to be affected by attention and both types of relevance. Considering the plot of cognitive curiosity (Figure H.3.1 in Appendix H) and the plot of attention (Figures H.1.1 and H.1.2 in Appendix H) and of relevance (Figure H.2.1 – Figure H.2.3 in Appendix H), it was considered that the values of cognitive curiosity were influenced by the values of either one or both of these motivational states. One may argue that the values of these motivational states at some specific points are not rigorous which seems to be true according to the data. However, it is known in the literature (e.g. Reid, 2006) that there is an issue about the reliability of the data received from using a self-report technique and also, in our view, there is a trade-off between rigour and pragmatism as this research aims at exploring the relationships which to some extent, are ‘hidden’. Thus, a pragmatic model was considered to be appropriate and to contribute to the development of a more rigorous model. According to this, we tend to consider the values of these motivational states in terms of approximation rather than precision; for example, the value of high or of very high were considered to be approximately the same as the value falls into the high-value category. Also, as can be seen from the graphs of cognitive curiosity, some cases (cases E02 and E12) reported to have a low level of cognitive curiosity and were not able to report their curiosity level at some points in the game; this indicates that some features in the game should be adjusted. Based on the comments from the participants, it was considered that the features: content and feedback, could be changed in order to increase the level of cognitive curiosity. For example, the task could be more complicated to keep the participants’ interest. Also, the same feedback style used in both tasks was reported to be uninteresting and thus, the feedback could also be changed.

Effort is the motivational state which was sketched to be affected by cognitive curiosity according to the preliminary model. However, in this revised model effort was considered to be affected by attention and both long-term and short-term relevance. According to the plot of effort (Figure H.4.1 in Appendix H) and the plot of attention (Figures H.1.1 and H.1.2 in Appendix H) and of relevance (Figure H.2.1 – Figure H.2.3 in Appendix H), it was considered that the values of effort at different points in the game were influenced by the values of either attention or relevance (both types), or both. On the other hand, when comparing the values of cognitive curiosity and of effort at different points in the game, the values, generally, are opposite. Based on this piece of information, it was considered to be sensible that the link between cognitive curiosity and effort (as appeared in the preliminary model) should be removed in this refined model and the links from attention, long-term relevance and short-term relevance to effort should be created instead. Again, we are inclined to consider the values of these motivational states in the aspect of approximation similar to what we did for cognitive curiosity. In addition, as can be seen from the graphs of effort, one ‘learner’ (case E02) reported to use a low effort or was not able to report the level of effort used at some specific points in the game; this shows that some features in the game should be adjusted. Based on the comments from the participant, it was considered that the feature – content could be changed in order to increase the use of effort (e.g. more challenging activity/task could be employed).

Confidence is the motivational state which was sketched to be affected by effort according to the preliminary model. However, in this revised model confidence was considered to be affected by both long-term and short-term relevance, effort and some outside factors (experience and during-session performance). These factors were not included in the preliminary model since they could not be categorised as either motivational characteristics or ILE features. According to the plot of confidence (Figure H.5.1 in Appendix H) and the plot of attention (Figures H.1.1 and H.1.2 in Appendix H) and of relevance (Figure H.2.1 – Figure H.2.3 in Appendix H), it was considerd that the values of confidence at different points in the game were influenced by the values of either attention or relevance (both types), or both. Nevertheless, the values of confidence at some specific points in the game seemed not to be affected by any of these motivational states, and thus, we suspected that in this case confidence might be influenced by the outside factors as explained in the analysis of each individual case. According to the graphs of confidence, all participants reported to have a high confidence throughout the interaction session with the game and when they were asked to report their motivation at the end of the session, they reported to feel motivated to both learn and play. According to this, the extra two nodes were added to the model to represent the motivation-to-learn and the motivation-to-play. The links between confidence and these two nodes were also created to represent the relationship between confidence and motivation. These links were created based on not only the evidence gathered from the participants, but also the ARCS model of Keller (1983) which suggests that confidence is supposed to be achieved by a student in order to feel motivated to learn with an instruction.

In this refined model attention, long-term relevance and short-term relevance are termed as ‘initial states’ since they were considered to be the states which were affected immediately by the features of an ILE. The reason for which these motivational states were considered to be affected instantly is because according to Keller’s (1983) ARCS model, these motivational states are the first two characteristics which should be achieved in order for a student to be motivated to learn with an instruction. However, from our revised model it is not clear whether attention occurs before relevance unlike ARCS in which attention is claimed to be the first characteristic to occur. We argue that our model focuses more on revealing how the motivational states of a learner are related in the context of an educational game rather than specifying the precise order of these states. Furthermore, based on the data, both attention and relevance were considered to play an important role in the motivation of the ‘learners’ since the values of both motivational states were considered to change in the same direction. In addition, relevance was considered to have a strong impact on motivation when learning in this context as one participant (case E02) seemed not to have any feeling to learn from the game at the beginning, but, he expected to enjoy playing the game instead (long-term relevance). However, his feeling to learn was reported to occur later during interaction (short-term relevance) resulting in the feeling of being motivated to learn at the end of the game.

As for cognitive curiosity, effort and confidence, they were considered to be the motivational states that were affected after attention and both types of relevance. In the preliminary model these motivational states were considered to be influenced by attention and relevance and they were also considered to occur in chronological order. In the revised model these three motivational states still seem to be affected by attention and relevance according to the comparison of the plots of these motivational states. However, it is difficult to specify whether the order exists. According to the plots of all motivational states (Appendix H), it was considered that effort might not be influenced by cognitive curiosity since the graphs seem not to change in the same direction. Rather, the values of effort were considered to be affected by the values of attention and both types of relevance as previously explained. Nevertheless, effort was considered to have an influence on the confidence state of the participant since the graphs of both motivational states seem to change in the same direction in general. Based on this piece of information, cognitive curiosity, effort and confidence are termed as 'consecutive states' which refers to the motivational states that were affected after the initial states.

## 8.4 The Causal Model of Motivation of 'Non-Learners'

The causal model of the 'non-learners' is shown in Figure 8.2. The story of the model can be told as two related parts similar to that of the 'learners'.

Similar to the explanation made for the model of the 'learners' in the previous section, the first part of the model shows the relationships between the trait characteristics of the 'non-learners' (independent variables), and the features of an ILE (dependent variables that vary according to the trait characteristics). These relationships are represented by links.

When looking at all three cases in the 'non-learners' group, there is a variety of trait combinations similar to that of the 'learners'. For instance, case E01 is a high-control, high-challenge and high-independence type. On the contrary, case E04 is a high-control, high-challenge and low-independence type whereas case E09 is a high-control, low-challenge and high-independence type. As a result of the different combinations of the trait characteristics, these cases were assigned to play different versions of the game which were tailored to suit their characteristics. The links shown in this part of the model are similar to those that appeared in the model of the ‘learners’ except for the associated text of the links between control and the features: content and cognitive tool. Only the text ‘high’ is shown since all cases reported that they prefer to have a high control in a learning situation; however, the text ‘low’ might be added if there were ‘non-learners’ cases who preferred to have a low control. The relationships between the trait characteristics of a ‘non-learner’ and the ILE features can be illustrated in the same way as the example given for the ‘learners’ group. Take the trait ‘challenge’ as an example, a ‘non-learner’ who prefers a high challenge in a learning environment (represented by the text ‘High’) was offered the learning environment that provides a challenging feedback such as a guided feedback[4] (represented by the symbol ‘+’ which refers to ‘causal influence in the same direction as the starting node’). Similarly, a ‘non-learner’ who prefers to a low challenge (represented by the text ‘Low’) was offered the learning environment that provide a less challenging feedback such as a direct feedback[5] (represented by the symbol ‘+’ which refers to ‘causal influence in the same direction as the starting node’).

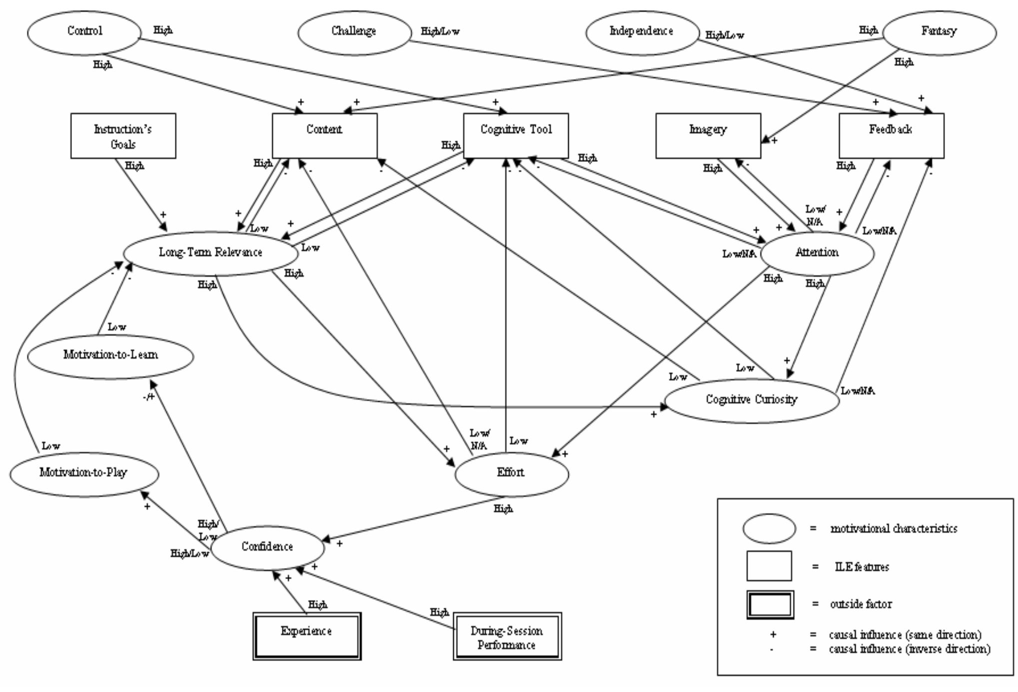


Figure 8.2: The revised causal model of motivation of ‘Non-Learners’

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[4] When a participant who preferred to learn in a high-challenging situation did the tasks in the game wrongly, a clue/hint to the right answer (guided feedback) would be given to him/her.

[5] When a participant who preferred to learn in a low-challenging situation did the tasks in the game wrongly, the correct answer (direct feedback) would be given to him/her straight away.

The second part of the model shows the relationships between the ILE features and the state characteristics of the 'non-learners'. Similar to the explanation made for the model of the 'learners', the ILE features and the state characteristics can be viewed as both independent and dependent variables, and the relationships among them are represented by links. There are a few differences between this part of the model and that of the preliminary version. These differences are the same as those of the 'learners' as explained in section 8.2. Comparing this part of the model (Figure 8.2) to that of the 'learners' (Figure 8.1), it was noticed that the links that appeared in both models are different. Also, there is a difference in the motivational states that appeared in both models. In the model of the 'learners', the motivational state 'short-term relevance' exists as there was a case (case E02) who seemed not to have the goal in learning at the beginning of the game, but the goal was developed later during interaction. As a result, the motivational state 'relevance' was divided into two sub-states: long-term relevance and short-term relevance (see section 8.2 for further explanation). However, in the model of the 'non-learners', the state 'short-term relevance' is not presented as there was no case like case E02 in this group.

When looking at all cases, attention was the motivational state which was considered to be affected by three features of the game: cognitive tool, feedback and imagery similar to that of the model of the 'learners'. It was mentioned earlier that all cases in the 'non-learners' group played two versions of the game (the original version and the adjusted version) as they were not motivated to learn after playing the first game (the original version) and thus, they were asked to play the second game (the adjusted version). According to the plots of attention in the first play[6] (Figures I.1.1 and I.1.3 in Appendix I), the imagery used in the first game could attract the attention of a 'non-learner' (case E04) in general. This case also reported to feel attracted to the use of the cognitive tool, but he did not pay much attention to the feedback given when he was doing the tasks in the first game. As for the other cases in the 'non-learners' group (case E01 and case E09), the imagery used in the first game was reported to be able to draw their attention. However, there were some points in the game where they reported to pay low attention or were not able to report the attention level paid to the imagery. Also, both of them reported to pay low attention to the use of the cognitive tool to explain the database knowledge embedded in the game.

[6] The first play refers to the play with the original version of the game.

According to the plots of attention in the second play[7] (Figures I.1.2 and I.1.4 in Appendix I), the attention level paid to the imagery of case E04 was similar to that in the first play. Furthermore, it was reported to be higher in the scenes in which evident changes in the imagery were presented for the first time (snapshot 4).It looks like the changes in the imagery also have an effect on his attention paid to the feature – feedback, as he reported to pay higher attention to this feature when it was given during the tasks of the second game. On the contrary, the attention level of case E01 in the second play was likely to be lower than that in the first play whereas case E09 seemed to pay the same level of attention to the imagery used in both games; however, the attention of case E09 paid to the features: feedback and cognitive tool, in the second game were likely to be lower than those in the first game. Based on this evidence, it was considered that all features related to the attention state could be adjusted in order to raise the value of the motivational state. The second game could have been made more different compared to the first game to attract the attention of the 'non-learners'.

On the other hand, long-term relevance was the motivational state which was considered to be affected by two features of the game: instructional goals and content similar to that of the model of the 'learners'. According to the plots of relevance in the first play (Figures I.2.1, I.2.3 and I.2.5 in Appendix I), it seems that two 'non-learners' (case E04 and case E01) felt interested in database knowledge embedded in the game at the beginning of the interaction; also, they anticipated enjoying whilst playing the game. However, as they progressed through the game, case E04 was not able to report his interest to learn in a game environment whereas case E01 obviously reported to have low interest to learn from the game. As for the feeling of fun, it seems that both cases felt higher fun when they played the first half of the game (the 'non-serious' bit[8]), but this did not seem to be the case when they played the second half of the game (the 'serious' bit[9]).

Case E04 reported to feel a high coherency in the storyline at the end of the game as well as case E01. However, case E01 reported not to be able to see the knowledge embedded in the task whereas case E04 reported not to feel impressed with the way in which the knowledge was presented since he made a further comment that the process of showing which attribute belongs to which entity was not obvious. On the contrary, case E09 reported to have a low interest in learning databases from the start of the game and

[7] The second play refers to the play with the adjusted version of the game.

[8] The 'non-serious' bit refers to the part in the game that is not relevant to learning databases.

[9] The 'serious' bit refers to the part in the game that is relevant to learning databases.

she also reported to have a low feeling of fun after having a glimpse of the story. As she progressed through the game, she reported to be able to see the database knowledge, but she did not feel happy to learn from playing the game. The participant also reported to have a low feeling of fun throughout the game. When she was asked about the feelings towards the content of the game, she reported to feel a high coherency in the storyline and she could see the database knowledge embedded in the game. However, she was neither happy to learn nor play with the game since the story was predictable and the tasks were not challenging. Nevertheless, she did not mention anything regarding the database knowledge which was different from the other two cases.

Such evidence seemed to contrast with what she reported when she was asked about the database knowledge in the game. Thus, it was considered to be possible that case E09 might not understand the database knowledge embedded in the game. Based on this, it was considered that the needs/expectations of the 'non-learners' might not be met during the game interaction.

When they were asked about their opinion towards the game, they made some comments that the storyline, the way in which the knowledge embedded in the tasks was presented and the way in which the knowledge was presented explicitly after the tasks could be improved to make the game more interesting. It seems that these comments involve the features: content, imagery and cognitive tool. As a result, these features could be adjusted in order to raise the value of the long-term relevance state (e.g. the more complicated story, the use of the audio text instead of visual text, etc.).

In sum, it was considered that the features: instructional goals and content could exert some influence on the state of long-term relevance. Some 'non-learners' seemed to have the needs/expectations that matched with the instructional goals from the beginning of the game (instructional goals – long-term relevance); however, the content did not seem to fulfil their needs (content – long-term relevance) throughout the rest of the game. When each of the 'non-learners' finished playing the first game, they were asked to report their motivation to both learn and play. Two of them (case E04 and case E01) reported to feel motivated to play, but not to learn whereas the other 'non-learners' (case E09) reported not to feel motivated to both learn and play.

Since all cases in the 'non-learners' group were not motivated to learn from playing the first game, they were asked to play the second game (the adjusted version of the first game). In the second play there was an obvious change in the values of the long-term relevance state of case E04. As can be seen from the plots of relevance in the second play (see Figures I.2.1, I.2.3 and I.2.5 in Appendix I), this case seemed to have the goal in learning from the start of the game and this goal seemed to be fulfilled throughout the interaction with the second game. Also, his feeling of fun was obviously higher than that in the first play. When he was asked about his motivation at the end of the second game, he reported to feel motivated to both learn and play. It was considered that the reason for why this case was motivated to learn with the adjusted version of the game was because the game was changed in a way that matched with his recommendations. As mentioned earlier, case E04 made a comment that the way in which the knowledge embedded in the tasks was presented could be changed to make it appear clearer to a learner. And, in the adjusted version of the game there was an improvement in the presentation of the knowledge (the process of moving the right attribute to the selected entity was more obvious). However, it seems that the second game did not have an effect on the motivation of case E01 and case E09. Case E01 still reported to have a low interest to learn by playing the game and his feeling of fun were lower than that in the first play. When he was asked to report his motivation at the end of the second game, he still reported to feel motivated to play the game, but he was not motivated to learn from it. According to his comment about the first game, the cognitive tool was supposed to be presented before the tasks were given so that he could use the knowledge gained from the explanation of the tool to solve the problems in each task and the second game was not much different from the first game – only some graphics were changed. It was considered that the reason for why this case was still not motivated to learn after playing the second game was because the game was not adjusted in the way he expected to be.

As for case E09, the participant reported to have similar feelings as when she played the first game. Her interest to learn and her feeling of fun was reported to be low throughout the second game. When she was asked to report her motivation at the end of the game, she still reported not to feel motivated to both learn and play. It was considered that the reason for why this case was still not motivated to learn was because she seemed not to understand the database knowledge in the tasks. The participant reported to be able to see the knowledge embedded in the tasks, but she still did not feel happy to learn from playing the game. However, when she was asked to provide further comments regarding the game, she did not mention anything relating to the database knowledge. Rather, the comments that she made involved superficial issues such as graphics, the storyline and the techniques that made the game more interesting and challenging.

Cognitive curiosity of the ‘non-learners’ was the motivational state which was considered to be affected by attention paid to the imagery used in the game and the feelings that the game was relevant to his goal in having fun when playing it. As can be seen from the plots of cognitive curiosity in the first and the second play (Figure I.3.1

and I.3.2 in Appendix I) and the plots of attention (Figure I.1.1 – I.1.4 in Appendix I) and of relevance in both plays (Figure I.2.1 – I.2.6 in Appendix I), it was considered that the values of cognitive curiosity were influenced by the values of either one of these motivational states, or both. However, the values of these motivational states at some specific points in both games are not exactly the same. The same argument made for the model of the 'learners' can also be made for the model of the 'non-learners' (see section 8.2 for the argument). Thus, we are inclined to consider these values in terms of approximation rather than precision. Also, as can be seen from the graphs of cognitive curiosity, the cases in the 'non-learners' group reported to have a low level of cognitive curiosity or not to be able to report their curiosity at some points in both games. This indicates that some features in the game could be adjusted. Based on the comments from the participants, it was considered that the features: content, cognitive tool and feedback, could be changed in order to increase the level of cognitive curiosity. For example, the task could be more complicated to keep their interests. The story could be changed by making the cognitive tool appear before the tasks. Also, the same feedback style used in both tasks was not interesting and thus, the feedback should be adjusted to arouse the cognitive curiosity of the participants.

Similar to cognitive curiosity, effort was the motivational state which was considered to be affected by attention paid to the imagery and the feelings that the game was relevant to his goal in having fun when playing the game. According to the plots of effort in the first and the second play (Figures I.4.1 and I.4.2 in Appendix I) and the plots of attention (Figure I.1.1 – I.1.4 in Appendix I) and of relevance in both plays (Figure I.2.1 – Figure I.2.6 in Appendix I), it was considered that the values of effort were influenced by the values of either one of these motivational states, or both. As previously explained in section 8.2 (page 9), we tend to consider these values in the aspect of approximation rather than precision since it was considered that a pragmatic model seems to be appropriate in this research context (exploratory research) and to contribute to the development of a more rigorous model. In addition, based on the data, some 'non-learners' (case E01 and case E09) reported to use a low effort or were not able to report their level of effort used at some points in the game. This shows that some features in the game should be adjusted. Based on the comments from the participant, it was considered that content was the feature that could be changed in order to increase the use of effort. For instance, the activity/task could be made more challenging to promote a higher level of effort employed in playing the game.

Confidence of the 'non-learners' was the motivational state which was considered to be affected by long-term relevance, effort and some outside factors (experience and during-session performance) similar to the model of the 'learners'. According to the plots of confidence in the first and the second play (Figures I.5.1 and I.5.2 in Appendix I) and the plots of attention (Figure I.1.1 – Figure I.1.4 in Appendix I) and of relevance in both plays (Figure I.2.1 – Figure I.2.6 in Appendix I), it was considered that the values of confidence at different points in both games were influenced by the values of either attention or relevance (both types), or both. Nevertheless, the values of confidence at some specific points in the games did not seem to be affected by any of these motivational states, and thus, we suspected that in this case confidence might be influenced by some outside factors as explained in the analysis of each individual case.

At the end of the game all three cases were asked to report their motivation. Two 'non-learners' (case E04 and case E01) reported to feel motivated to play the game, but not to learn from it. On the other hand, another 'non-learner' (case E09) reported not to feel motivated to both learn and play. According to this, the extra two nodes were added to the model to represent the motivation-to-learn and the motivation-to-play. The links between confidence and these two nodes were also created to represent the relationship between confidence and motivation. Similar to the model of the 'learners', these links were created based on not only the evidence gathered from the participants, but also the ARCS model of Keller (1983) as explained in section 8.2. Also, a link was drawn from the motivation-to-learn to long-term relevance and from the motivation-to-play to long-term relevance. These links demonstrate that in order to create motivation in learning the participants were supposed to have an interest to learn from the game and that the game should be able to satisfy them. In other words, the relevance between their goal in learning by playing the game and the instructional goal (support learning) was supposed to be established and thus, the value of long-term relevance was supposed to be increased since the two 'non-learners' who were still not motivated to learn after playing the second game did not seem to have an interest in learning when playing both games. It was considered that a few ways could be used to create the interest to learn from the game. One way was to change the imagery used for representing the knowledge embedded in the task and this technique was successful in motivating case E04 to learn through the game environment. Another way was considered to be making an adjustment to the content, either the storyline (make it more interesting) or the knowledge itself (make it more complicated and more challenging).

# 8.5 Discussions of the Models

Earlier, we presented the refined causal models for a group of participants who felt motivated to learn in the game-based learning context ('learners') and for a group of participants who did not feel motivated to learn in this context ('non-learners'). In line with the old saying "One picture is worth a thousand words", the descriptions of the models were created in order to create the same understanding and interpretations towards the model.

In this section we move to discuss some issues that relate to the models.

**Issue 1: Were the participants assigned to the right version of the game?**

Since both causal models of motivation were created based on the interaction between the participants and the game prototype, one may question whether the participants were assigned to play the 'right' game as several versions of the game were developed to use in the study[10]. To eliminate this suspicion, it seems that firstly, the term 'the right version' needs to be clarified. To us, 'the right version' means the version of the game which is tailored according to the trait characteristics of a particular participant and is the version which is likely to motivate him/her to learn; however, 'the right version' may not be 'the best version' or the version in which a participant feels motivated the most. Secondly, we need to refer to de Vicente's (2003) work once again in order to explain this. He stated in his work that

> "The trait variables aim to provide the system with a general picture of the goals it should pursue with a particular student. But, to represent these personality characteristics as simple variables is no doubt a tradeoff between rigour and pragmatism. For example, a measure of how much fantasy a student likes during an instructional interaction is an oversimplification of all the complex aspects affecting this particular construct. On the other hand, even a general and simple approach like this can help to create a better tutoring system, better 'tuned' to a particular student." (p.47).

[10] All participants were assigned, by MoRes, to play only one version of the game and they would not be assigned to play the other version unless they reported not to feel motivated to learn after they finished playing. If it were the case that the participants were not motivated to learn from the game, they would be asked to play the adjusted version which was created based on the version that they played before.

The trait characteristics – ILE features part of the model was created based on the idea of trying to 'tune'[11] a game-based learning environment to a particular participant by obtaining the major preferences from him/her. The contingency table (Table 8.1) was created in order to show the dependency between the game which was tailored according to the trait characteristics of the participant and his/her motivation to learn. Also, a graphical way to represent the data from the table was produced as can be seen from Figure 8.3.

| Game | Outcome = MOL | Outcome = NMOL | Total |
|---|---|---|---|
| v2.0 | 21 (91%) | 2 (9%) | 23 |
| v3.0 | 2 (100%) | 0 (0%) | 2 |
| v4.0 | 1 (50%) | 1 (50%) | 2 |
| Total | 24 | 3 | 27 |

Legend: MOL = Motivated-to learn
NMOL = Not Motivated-to-learn

Table 8.1: The dependency between the game and motivation to learn of all participants

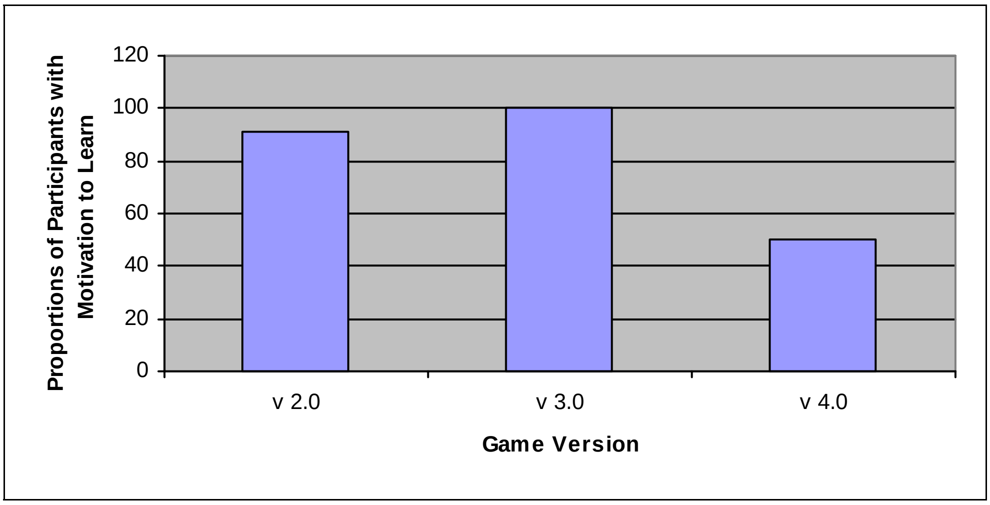


Figure 8.3: The dependency between the game and motivation to learn of all participants

As can be seen from both Table 8.1 and Figure 8.3, the majority of the participants (24 out of 27 participants) reported to feel motivated to learn. Hence, it seems sensible to assume that they were assigned to 'the right version' of the game.

However, there were three participants who reported not to be motivated to learn at the end of the game and as a result, they were asked to play the adjusted versions of the game. These adjusted version were developed based on the version which they just finished playing (see more details on the adjusted versions in section 5.3.1.4). After the session with the adjusted version was finished, each participant was asked to report

11 The term 'tune' can be defined as 'to make a learning environment to likely suit an individual learner'.

his/her motivation in learning and it turned out that one of them (case E04) reported to feel motivated to learn with the adjusted version. On the other hand, the other two participants (case E01 and case E09) still reported not to feel motivated to learn and based on the analysis of each individual case (see more details on the analysis of case E01 in Appendix F and of case E09 in chapter 7), it was considered that these two participants did not understand the knowledge embedded in the game. The participants seemed not to have the goal in learning from playing the game in the first place and neither version of the game succeeded in influencing the development of this goal throughout the game interaction. It was considered that the problem with both versions of the game was the way in which the knowledge embedded in the games was presented. As reported by one participant – case E01, the knowledge should be presented before the tasks were given (not the other way round) so that he could use it to solve the problems in the game. Based on this and the definition of the term 'the right version' as mentioned earlier, we are inclined to assume that this group of participants, to some extent, were also assigned to the right version as it was considered that the reason for why they were not motivated to learn, seemed to relate more to the relationships between the game features and their state characteristics.

**Issue 2: What are the general principles of the model?**

As suggested by Ogborn (1994), it is difficult for humans to understand many aspects of the world as it is and this is why simplified, idealized and stripped-down models are built. Such models have given many surprises and have led to new and powerful insights. Our causal models are such an attempt that tries to simplify the complexity of students' motivation when learning in a game-based learning environment. However, it is difficult to create a model that covers every aspect of motivation since we cannot really see what is happening inside one's mind. As a result, the models are discussed in the aspect of the general principles about what they can do or what they cannot do.

We considered our models as being likely to provide a better view of trait characteristics, the features of a game ILE and state characteristics relating in a game-based learning context. The model could shed some light on the issue of what is going on when students are motivated to learn or not motivated to learn with an educational game. From a reading of the literature (Keller, 1983; Malone & Lepper, 1987; del Soldato & du Boulay, 1995; de Vicente & Pain, 2002), several characteristics are likely to contribute to motivation in learning. As proposed by de Vicente (2003), motivation of a student is likely to comprise two characteristics: trait characteristics (permanent characteristics) and state characteristics (more transient characteristics which relate to the material being learnt). It was considered that the state characteristics seemed to play an important role in students' motivation during the instructional interaction and it would be useful if the hidden interaction among these motivational states could be pulled out so that we could seek to manipulate them in a sound pedagogical manner. As a result, our models focus on the interaction among the motivational states which were considered to contribute to motivation in learning. The model could serve as qualitative guidelines for what was done or what was supposed to be done to the features of the game ILE to create the positive impacts on these motivational states. We obtained these guidelines from unfolding one of our research instruments – the game prototype: Alex's Adventure. By unfolding the game instruction, we came up with the strategies that could deal with the different kinds of motivational states during the game interaction (as shown in case dynamic matrices developed for each case study). In addition, our models reveal the motivational patterns[12] of two groups of students: 'learners' (students who are motivated to learn) and 'non-learners' (students who are not motivated to learn)

Nevertheless, there are some limitations in our causal models of motivation. As can be seen from the preliminary model in chapter 4, all motivational states were sketched out in chronological order. Attention and relevance were considered to be the two motivational states that were directly affected by the features of the game. Cognitive curiosity was considered to be affected by attention and relevance. Effort was considered to be affected by cognitive curiosity and confidence was considered to be affected by effort. However, the order of the last three motivational states in the preliminary model (cognitive curiosity, effort and confidence) is not clear in the refined version of the model. We know that attention and relevance were the motivational states that were likely to be affected directly by the features of the game ILE and thus, they were termed as the 'initial states'. We also know that cognitive curiosity, effort and confidence were the motivational states that were likely to be affected after and hence, they were termed as the 'consecutive states'. Nevertheless, we do not know whether the order among the consecutive states is like that appears in the preliminary model. Furthermore, it is not clear how much each of these motivational states contribute to motivation in learning. We have the impression that long-term relevance is likely to be the most important motivational state in the game-based learning context. This motivational state, if it exists in the first place, should be preserved throughout the game interaction. However, if it

[12] The term 'motivational patterns' refers to the models of how a student is motivated or not motivated to learn in the context of an educational game.

does not exist in the first place, it should be influenced to occur during interaction (short-term relevance) since this type of relevance is likely to contribute to motivation in learning, but to a lower degree compared to long-term relevance (see also key point 3 in section 8.5). However, for both types of relevance and for the other motivational states, we do not know how much the importance is in term of quantity. It was considered that if this issue can be resolved, it may contribute to the development of the numerical/computational model.

## 8.6 Key Points from the Case Study Analysis

In the previous chapter the plots of the motivational states at different points in the game were created for each individual case. However, it was considered that there were some similarities and some differences among these plots and thus, all cases were divided into two groups for the discussion purpose as explained earlier ('learners' and 'non-learners'). As a result, the plots of the motivational states of each group were created in order to provide a better insight into the similarities among the cases in each group and in looking for some key points that could be drawn from all cases. Eight plots were created for the 'learners' group and 16 plots were created for the 'non-learners' group. One may doubt why the number of the plots created for the 'non-learners' is double compared to that of the 'learners'. As already explained in chapter 8, the 'non-learners' refers to the participants who reported not to feel motivated to learn with our game prototype which resulted in another play with the adjusted version of the game. Thus, 16 plots were created to demonstrate the motivational states of the participants in the first and the second play. The plots of the motivational states of the 'learners' appear in Appendix H and the plots of the motivational states of the 'non-learners' appear in Appendix I. There are a number of key points that can be drawn from these plots which were considered to be qualitative guidelines that would be of use for the design and the development of a computer program that implements the revised motivation model. These key points are presented as follows.

**Key Point 1:** By sustaining the feeling of fun, the feeling to learn by playing the game can be developed even though a learner does not have this feeling in the first place.

This key point was drawn from case E02. From the plots of relevance (Figures H.2.1 and H.2.2 in Appendix H), it seems that this case expected to have fun with the game from the beginning since the graph of the feelings that the game was relevant to his goal in having fun starts at the value of very high (Relevance Value = 5) in snapshot 1. On the contrary, the case seemed not to feel interested in learning when he started playing the game. However, his feeling to learn were reported to develop after he finished doing the first task (snapshot 4) and was presented with an explicit explanation regarding the knowledge embedded in the task (snapshot 5). The feeling was reported to be sustained at a high/very high level through the rest of the game. Nevertheless, his feeling of fun was also maintained to be high/very high throughout the game interaction and as a result, it was considered that, if the feeling of fun was sustained, to some extent, the feeling to learn could be developed even though the feeling did not exist in the first place. As for the 'non-learners' (case E04, case E01 and case E09), it was considered that the game was not able to sustain their feeling of fun in general (see Figure I.2.3 in Appendix I) which resulted in the low feeling of learning at the end of the game. However, when all cases were asked to play with the adjusted version of the game, the feeling of fun of case E04 was reported to be sustained at a high/very high level throughout the interaction (see Figure I.2.4 in Appendix I) as well as his feeling to learn from the game (see Figure I.2.2 in Appendix I). It was considered that this evidence could support this key point drawn from the study of case E02.

**Key Point 2:** The feeling to learn and the feeling of fun of the 'learners' seem to change in the same direction once a student feels interested to learn.

As can be seen from the plots of relevance (Figures H.2.1 and H.2.2 in Appendix H), the graphs of case E10 and case E12 generally fall into the high-value area throughout the interaction with the game. However, as for case E02, the graphs of relevance are likely to change in the same direction when the participant started to have the feeling to learn from playing the game (snapshot 5). Other supporting evidence can be seen from case E04 who changed from being a 'non-learner' when playing the first game to being a 'learner' when playing the second game (the adjusted version of the first game). The graphs of his feelings of relevance also seem to change in the same direction (see Figures I.2.2 and I.2.4 in Appendix I).

**Key Point 3:** The state of relevance (both long-term and short-term) seems to play an important role in the overall motivation in learning for both 'learners' and 'non-learners'. That is, if a student feels that his/her needs relating to learning are achieved throughout the interaction with the game ILE (long-term relevance) or his/her feeling to learn is influenced to occur during interaction with the game (short-term relevance), he/she tends to be a ‘learner’ rather than a ‘non-learner’.

As can be seen from the plot of relevance of case E10 and case E12 (Figures H.2.1 in Appendix H), the graphs, generally, fall into the high-value area (Relevance Value = 4 and Relevance Value = 5) which show that these two cases considered the game as being able to fulfill their needs throughout the game interaction. Based on this evidence, both of them were considered to have the feelings that the game was relevant to their needs in long-term. However, the graph of relevance of case E02 is slightly different. The graph starts from the low-value area (Relevance Value = 1 and Relevance Value = 2) before gradually increasing to the high-value area later in the game. This incident can be regarded as supporting evidence for making an inference that case E02 had the feelings that the game was relevant to his goal in learning in short-term (refers to the analysis of case study 1: case E02 in chapter 7). Both short-term and long-term relevance were considered to play an important role in the overall motivation of the ‘learners’ since all three cases (case E02, case E10 and case E12) in this group reported to feel motivated to learn at the end of the game.

**Key Point 4:** It seems that the ‘learners’ tend to have positive feelings towards the use of the cognitive tool in explaining the knowledge embedded in the game ILE explicitly whereas the ‘non-learners’ tend to have negative feelings towards this feature. However, a ‘learner’ who feels that the game is relevant in short-term (short-term relevance) is likely to have a lower level of positive feelings compared to those who feels that the game was relevant in long-term (long-term relevance). Hence, if the short-term relevance can be changed into long-term relevance, it seems to secure the high level of motivation in learning. The issue is how since the feelings of relevance seem to involve with expectation which is not included in our model.

As can be seen from the plots that appear in Appendix H, case E10 and case E12, who were considered to have the feelings of long-term relevance, reported to pay a very high level of attention whenever the cognitive tool was presented in the game. Also, they reported to feel curious about the explanations given by the tool and to put a very high effort on learning from these explanations. However, case E02, who was considered to have the feelings of short-term relevance, reported to pay a slightly lower attention to the tool. He also reported to feel highly curious when the explanation was given after the first task was finished, but he was not able to report his curiosity level after the second task was finished. Nevertheless, he reported to use a very high level of effort to learn from both explanations. As for the 'non-learners', most of them (case E01 and case E09) reported to pay a low attention to the appearance of the tool in both games. They also reported to have a low curiosity when the explanations were given by the tool and they reported not to make an effort in learning from those explanations. However, this did not seem to be the case for case E04 as he reported to have the positive feelings towards the cognitive tool in both games even though he was categorised to be one of the 'non-learners' in the first place.

**Key Point 5:** The state of cognitive curiosity of the 'learners' is the motivational state in which its value is likely to change in the same direction as attention and both short-term and long-term relevance. However, the cognitive curiosity of the 'non-learners', generally, seems to change in the same direction as attention paid to the imagery used in the game and the feelings that the game was relevant to the goal in having fun.

The supporting evidence for the 'learners' group can be seen from the plots of cognitive curiosity, of attention and of relevance (see Figures H.1.1, H.1.2, H.2.1, H.2.2 and H.3.1 in Appendix H). According to the plots, one may argue that the graph of cognitive curiosity does not seem to fit well with that of either attention or relevance. However, when looking at the value of these three motivational states at each specific point in the graph, the value of cognitive curiosity falls into the same area as the value of either attention or relevance, but, it is difficult to specify whether cognitive curiosity relies more on attention or relevance as the values seem to vary from one case to another and also, from one specific point to another. Similarly, the supporting evidence for the 'non-learners' group can be seen from the plots of cognitive curiosity, of attention paid to the imagery and of relevance. A similar explanation can be put forward for this group. However, it was noticed that the level of cognitive curiosity of most 'non-learners' (case E04 and case E01) was higher when playing in the first half of the first game compared to when playing in the second half of the game. This might be because in the first half of the game, new scenes were introduced and the story was not revealed much. However, in the second half of the game, there were some similarities between the first task (appeared in the first half of the game) and the second task (e.g. the settings, the nature of the task). These similarities might be the reason why the level of cognitive curiosity of case E04 and case E01 was reported to be lower in the second half of the game. Nevertheless, this did not seem to be the case for case E09 since the participant reported to have a low level of cognitive curiosity throughout the game.

**Key Point 6:** The state of effort of the ‘learners’ is the motivational state in which its value is likely to change in a similar fashion as attention and both short-term and long-term relevance. However, the effort of the ‘non-learners’, generally, seems to change in a similar fashion as attention paid to the imagery and the feelings that the game was relevant to the goal in having fun.

According to the plot of effort (see Figure H.4.1 in Appendix H), the graphs of all cases in the ‘learners’ group, generally, fall into the high-value area similar to the plots of attention and of relevance (see Figures H.1.1, H.1.2, H.2.1 and H.2.2 in Appendix H). Similar to the explanation made for key point 5, it is difficult to specify whether effort relies more on attention or relevance since the values seem to vary among cases; also, the values seem to vary among different points in the game. However, the graph of case E02 is slightly different from that of case E10 and case E12; there was a point in the game where a low effort was reported to be used and it was the point before his feeling to learn started to develop. It was considered that case E02 might not try to reflect the knowledge hidden in the task since he seemed not to have the expectation to learn from the start of the game which was different from case E10 and case E12. As for the ‘non-learners’ group, the graph of effort does not seem to fit well with that of either attention or relevance. However, when looking at the value of these three motivational states at each specific point in the graph, the value of effort falls into the same area as the value of either attention or relevance.

**Key Point 7:** The state of confidence of the ‘learners’ is the motivational state in which its value seems to change in the same direction as long-term relevance. However, for a particular learner, if there is more than one kind of long-term relevance (long-term relevance – the instructional goal: support learning and long-term relevance – the instructional goal: providing fun), confidence is likely to rely more on the one with the higher level. On the contrary, the state of confidence of the ‘non-learners seems to be influenced by some outside factors instead.

Consider case E12 as an example. This case was considered to have feelings that the game was highly relevant to her goal in learning and her goal in having fun when playing the game as the plots of relevance fall into the high-value area from the beginning to the end of the game (see Figures H.2.1 and H.2.2 in Appendix H). However, confidence seems to rely more on the feelings that the game was relevant to the goal in learning (long-term relevance – the instructional goal: support learning) as the plot of confidence is more similar to that of the feelings of relevance which was measured against the instructional goal: support learning (see Figure H.5.1 in Appendix H for the plot of confidence). A similar explanation can be made for case E10. However, a slightly different explanation can be put forward for case E02. The case seemed to have the expectation to have fun when playing the game from the beginning and the game could fulfill his goal (long-term relevance – the instructional goal: provide fun); however, his feeling to learn from the game was reported to develop later during interaction with the game (short-term relevance – the feelings that the game ILE was relevant to his goal in learning, which were developed during interaction).

When comparing the plot of confidence to that of both types of relevance, the graph of confidence is likely to match with that of long-term relevance. Nevertheless, there are a few points in the plot of confidence where the values do not seem to be consistent with those of long-term relevance. It was considered that this might be because some outside factors (experience and during-session performance) might play a part in the confidence of the 'learners' (see the analysis of each individual case who was categorised to be in this group). On the contrary, the confidence state of the 'non-learners' does not seem to change in the same direction as the long-term relevance state. The plots of confidence of all cases are not similar to those of long-term relevance. Thus, it was considered that the high-value of confidence might be influenced by some outside factors such as experience and during-session performance. According to the data, all 'non-learners' cases reported to have some background in databases and some of them took a database modeling course before (case E01 and case E09). Also, two of them (case E04 and case E09) performed very well when they were asked to do the tasks in the game. Based on this evidence, those two outside factors were selected.

**Key Point 8:** The values of the motivational states of the 'non-learners' in the second play, generally, seemed to be lower than those in the first play. However, this did not seem to be the case for the participant who changed from being a 'non-learner' in the first play to a 'learner' in the second play.

The 'non-learners' refers to the participants who were asked to play two games since they reported not to feel motivated to learn after playing the first game which led to another play with the adjusted version of the game. It can be seen from the comparison between the plots of all motivational states in the first play and that of the motivational states in the second play that, generally, the values of the motivational states are the same or lower for the cases who were still the 'non-learners' (case E01 and case E09). However, the values of some motivational states (such as attention paid to the features: feedback and cognitive tool, and confidence) were reported to improve for case E01. As for the case who changed from being a 'non-learner' to a 'learner' in the second play (case E04), the values of the motivational states were reported to be higher. For example, there was an evident improvement in the attention paid to the features: feedback and cognitive tool. Also, the feelings of relevance were reported to be obviously higher. Furthermore, his confidence level was reported to be higher than that in the first play. Nevertheless, in some parts of the game (such as the beginning and the end) where no changes were made, the values of some motivational states (such as cognitive curiosity and effort) were reported to be the same or lower.

## 8.7 The Condition-action Rules

As previously explained in chapter 6, MoRes is one of the computer-based research instruments. It was developed to get the data concerning the trait characteristics of a student in order to assign the game that is likely to suit him/her. When the student finished playing the game, he/she would be asked to provide the data regarding some initial state characteristics (attention and relevance). After MoRes received these data, it would infer the value of the consecutive state characteristics (cognitive curiosity, effort and confidence) based on some rules. It was considered that MoRes was created in rather an ad hoc way and this approach had a deficiency; as stated by Ogborn & Miller (1994) that,

> "The deficiency of ad hoc modelling is the difficulty of analysing the model to see what it could possibly do or not do. For this reason, a number of types of modelling formalism have been developed, which are more or less well-understood." (p. 35)"

In addition, it was found out from the study that there were some cases whose motivational structure seemed to be more complex than others' such as case E02, case

E04, case E01 and case E09. It was considered that some further rules could also be obtained from the in-depth analysis of these cases. Hence, in this section we present the condition-action rules which can be regarded as useful guidelines for the design and the development of a computer program that implements the revised motivation model.

There are two types of condition-action rules: the simple rules which focus on a single motivational state and the complex rules which focus on a single motivational state or a few related motivational states. The simple rules were obtained from the comparison between the plots of the motivational states of the 'learners' and those of the 'non-learners'. Also, the rules were created based on looking across the case dynamic matrices created for each individual case in both groups. On the other hand, the complex rules were obtained from the key points drawn from the analysis of 6 case studies. Eleven condition-action rules were created as shown below. Rule 1 – Rule 6 can be regarded as the simple rules whereas Rule 7 – Rule 11 can be regarded as the complex rules.

**Rule 1:** IF (attention is high/very high) THEN
{preserve the attention level by exploiting the features:
imagery/feedback/cognitive tool }

**Meaning:** If the value of attention is high or very high, then the attention of a student should be preserved by exploiting the features: imagery/feedback/cognitive tool (e.g. including more colourful graphics, etc.).

**Rule 2:** IF (attention is very low/low/n/a) THEN
{raise the attention level by adjusting imagery/feedback/
cognitive tool}

**Meaning:** If the value of attention is very low/low or a student is not able to report his/her attention, then the attention of the student can be raised by adjusting imagery/feedback/cognitive tool (e.g. using audio text instead of visual text for the explanation given by the tool).

**Rule 3:** IF (relevance of learning is high/very high) THEN
{check IF (the task has not been given before)
THEN {preserve the feelings of relevance by offering
the first task and explicitly presenting
the knowledge embedded in the task in a fantasy-
like way}

ELSE {preserve the feelings of relevance by offering
the second task and explicitly presenting
the knowledge embedded in the task in a fantasy-
like way }}

**Meaning:** If a student has a high/very high feeling to learn, then the game ILE should check whether the task has been given before. If the task has not been given yet, then the student's feeling to learn can be preserved by offering the first task to him/her. And, after he/she completes the task, the knowledge embedded in the task can be explained explicitly. However, if the first task has been given already, then the feeling of learning of the student can be preserved by offering the second task followed by the explicit explanation concerning the knowledge embedded in the task.

**Rule 4:** IF (relevance of learning is very low/low/n/a) THEN
{check IF (the task has not been given before)
THEN {raise the feelings of relevance by offering
the first task and explicitly presenting
the knowledge embedded in the tasks in a fantasy-
like way}
ELSE {raise the feelings of relevance by changing
the visual presentation of the second task}}

**Meaning:** If a student has a very low/low feeling to learn or he/she is not able to report the feeling, then the system should check whether the task has been given before. If the task has not been given yet, then the student's feeling of learning can be raised by offering the first task to him/her. And, after he/she completes the task, the knowledge embedded in the task can be explained explicitly. However, if the first task has been given already, then the feeling of learning of the student can be raised by offering the second task followed by the explicit explanation regarding the knowledge embedded in the task.

**Rule 5:** IF (relevance of fun is high/very high) THEN
{preserve the feelings of relevance by including more fun
elements }

**Meaning:** If a student has a high/very high feeling of fun, then the feeling should be preserved by including more fun elements (e.g. increasing the level of interactivity in the game ILE).

**Rule 6:** IF (relevance of fun is very low/low/n/a) THEN
{raise the feelings of relevance by increasing more fun elements
e.g. interactive activities/surprised events}

**Meaning:** If a student has a very low/low feeling of fun or he/she is not able to report this feeling, then this feeling can be raised by including more fun elements such as interactive activities or surprise events.

**Rule 7:** IF ((relevance of learning is low) AND (relevance of
fun is high/very high)) THEN
{sustain the feelings of relevance}

**Meaning:** If a student has a low feeling of learning and he/she has a high/very high feeling of fun, then the feeling of fun should be sustained in order to raise the feeling of learning. As explained in key point 1, by sustaining the feeling of fun, the feeling of learning is likely to be developed even though a 'learner' does not have this feeling in the first place. An example can be seen from case E02.

**Rule 8:** IF (attention towards the cognitive tool is high/very high THEN
{check IF (relevance of learning is high/very high
from the start)
THEN {preserve the feelings of relevance}
ELSE {check IF (relevance of fun is high/very high)
THEN {preserve the relevance of fun in
order to create the feelings of short-
term relevance}
ELSE {raise the relevance of fun by
increasing more fun elements e.g.
interactive activities/surprised
events}}}

**Meaning:** If a student pays a high/very high attention to the cognitive tool, then, the game ILE should check whether his/her feeling of learning is high/very high. If the student has a high/very high feeling to learn, then, the high feeling to learn should be preserved. If the student has a low feeling to learn, then, the system should check whether his/her feeling of fun is high/very high. If the student has a high/very high feeling of fun, then, this feeling of fun should be preserved in the hope that by sustaining the feeling of fun, the student's feeling of learning will be developed (short-term relevance). However, if the student has a very low/low feeling of fun, then, the feeling can be raised by including more fun elements such as interactive activities or surprise events. As explained in key point 4, the ‘learners’ tend to have positive feelings towards the use of the cognitive tool whereas the ‘non-learners’ tend to have negative feelings towards this feature. However, a ‘learner’ who has short-term relevance (or a learner whose goal in learning is developed later during interaction with the game ILE which is case E02) is likely to have a lower level of positive feelings compared to those who seem to have long-term relevance (case E10 and case E12). Thus, it was considered that if the feeling of learning could be developed (either short-term or long-term relevance), the students are likely to pay more attention to the tool.

**Rule 9:** IF (curiosity is high/very high) THEN
{preserve the curiosity level}
ELSE {raise the curiosity level by adjusting the feature – content, to
increase the feelings of relevance OR by adjusting the
feature – imagery/feedback/cognitive tool, to increase the
attention level}

**Meaning:** If a student has a high/very high curiosity when playing the game, then, the curiosity of the student should be preserved. If the student has a very low/low curiosity, then, his/her curiosity can be raised by adjusting the content of the game in order to increase the feelings of relevance or by adjusting the imagery/feedback/cognitive tool in order to increase the attention level. As explained in key point 5, the value of cognitive curiosity is likely to change in the same direction as the value of attention and of relevance.

**Rule 10:** IF (effort is high/very high) THEN
{preserve the effort level}
ELSE {raise the level of effort by adjusting the feature – content,
to increase the feelings of relevance OR by adjusting
the feature – imagery/feedback/cognitive tool, to increase
the level of attention}

**Meaning:** If a student put in a high/very high effort when playing the game, then, the level of effort used by the student should be preserved. If the student put in a very low/low effort when playing the game, then, the level of effort used by the student can be raised by adjusting the content of the game in order to increase the feelings of relevance or by adjusting the imagery/feedback/cognitive tool in order to increase the attention level. As explained in key point 6, the value of effort is likely to change in the same direction as the value of attention and of relevance.

**Rule 11:** IF (confidence is high/very high) THEN
{preserve the confidence level}
ELSE {raise the confidence by adjusting the feature – content to
increase the feelings of relevance}

**Meaning:** If a student has a high/very high confidence when playing the game, then, the confidence of the student should be preserved. If the student has a very low/low confidence when playing the game, then, the confidence of the student can be raised by adjusting the content of the game in order to increase the feelings of relevance. As explained in key point 7, for the 'learners' the value of confidence is likely to change in the same direction as the value of relevance. However, for the 'non-learners' the value of confidence seems to be influenced by some outside factors instead.

## 8.8 Summary

Six case studies were categorised into two groups: 'learners' and 'non-learners' for the discussion purpose in this chapter. The revised version of the causal model for each group was developed followed by the discussions regarding the models. Also, eight key points were drawn from the analysis of all six cases. Eleven condition-action rules were also created based on these key points and the analysis of the six cases. However, the key points and the rules were created as qualitative guidelines; thus, it depends on instructional designers/computer programmers to decide how to design and implement them into a computer program in order to make it functions as they require. In addition, the rules have to be supplemented with the ones that decide if it is desirable that the learner's motivation be increased at some point.

In the next chapter the summary of the research and findings will be made and other possible further work will be presented.

# Chapter 9

# Conclusions and Further Work

## 9.1 Summary of Research and Findings

According to the literature (see chapter 2), recent research points to the notion that motivation is a crucial factor when creating Interactive Learning Environments (ILEs) and Intelligent Tutoring Systems (ITSs). Furthermore, in the ITS community there has been a high interest in research that takes into consideration affective issues. The related research covers a large number of topics. Thus, by necessity the research tends to cope with a small and specific issue.

Similarly, the research presented in this thesis focuses on a specific issue. The focus of this research is on determining a motivational structure for the students and the way it may change in the context of an educational game. In other words, we tried to model the students' motivation during interaction with a game-based learning environment. The qualitative modelling approach was chosen for modelling learners' motivation since motivation was considered to be a dynamic and complex system which is difficult to inspect; using qualitative approach can reveal the complexity of such a system. As can be seen from the literature in chapter 2, several attempts have been carried out in order to model emotion. However, there has been little research that specifically focuses on the area of motivation modelling. We considered that research related to motivation modelling would be potentially of great benefit when creating learning environments and tutoring systems that 'care' about the students.

As also mentioned in chapter 2, the work of de Vicente (2003) relates to the detection of a student's motivational states in terms of a basic motivational model, based on self-report and the student's interaction with an ITS. We employed the motivation model that appeared in his work as a basis for the development of our preliminary causal model. The preliminary model was created aiming to be used within the educational game context since based on the literature in chapter 3, the association of motivation, educational games and narrative seems to be strong. The model was presented in chapter 4 and it shows the likely plausible cause-effect relationship between a learner's motivational characteristics and ILE features. In this research the term ‘motivational characteristics’ was defined as the motivational variables of the learners which can be placed into two categories (according to de Vicente & Pain’s (2002) motivation model): trait (permanent characteristics) and state (transient characteristics). The term ‘ILE features’ was defined as the basic elements that make up an ILE, particularly in the context of an educational game. The components of the model and the relationships were created based on a reading of the literature as explained in chapter 4.

In order to validate our preliminary causal model two computer-based research instruments were developed: the game prototype – Alex’s Adventure and the software prototype – MoRes. Several versions of Alex’s Adventure were created to be likely to suit the different combinations of the trait characteristics. The details regarding the design and the development of the game prototype were presented in section 5.3.1. As for the software prototype – MoRes it was created aiming at taking the approximate value of each trait variable from a particular student and provides him/her with the likely suitable version of the game. The prototype also takes the approximate values of some initial motivational states (attention and relevance) from the student and makes an inference regarding the value of the other consecutive motivational states (cognitive curiosity, effort and confidence) and his/her overall motivation at the end of the game. More details with regards to the design and the development of MoRes can be found in section 5.3.2.

Before performing the main study, the pilot study was conducted with two students from Glasgow University in order to test for the utility of all materials. The entire process involved in running the main study was also piloted. As a result of the study, the use of the webcam was found to be intrusive for one student. Thus, in the main study, each participant was asked whether he/she felt comfortable with the use of a webcam. The main study was performed with 27 students from the Department of Computing Science at Glasgow University. They were assigned by MoRes to play the version of Alex’s Adventure that is likely to suit their trait characteristics. Most of them (23 students) were assigned to play Alex’s Adventure 2.0; two of them were assigned to play Alex’s Adventure 3.0 and the other two students were assigned to play Alex’s Adventure 4.0. After running the study with all 27 students, 24 students reported to feel motivated to learn with the game instruction whereas 3 students reported not to feel motivated to learn.

As previously mentioned, we are interested in modelling motivation of the students using a qualitative approach, a case study analysis was chosen as a specific method for analysing the data for three main reasons:

1. The method is more suitable for answering the “how” research questions as explained in section 6.5.
2. The data gathered from individual students are rich and suitable for in-depth analysis.
3. It was considered that in order to determine the motivational structure across students, it is necessary to understand the structure of motivation within an individual student first.

As a result, we sought to investigate for both cases: those who were motivated to learn and those who were not. Six cases were selected for the purpose of the analysis. The first three cases were the motivated cases who played different versions of the game (Alex’s Adventure 2.0, Alex’s Adventure 3.0 and Alex’s Adventure 4.0) whereas the other three cases were the non-motivated cases out of the 27 student participants.

The results of each individual case were presented in two aspects using various representations: the description of an occurrence of motivation and the explanation about how motivation occurs and what causes it. The occurrence of the motivational states at different points during the game interaction was presented using two representations: an event listing for motivational state and the plot of motivational state. The effects of the game features on the motivational states of a single case were also presented using an effect matrix of ILE features. In order to explain the motivation of an individual case, the explanatory effects matrix was employed to provide us a notion of causes and effects between two types of variables in the game-based learning context: the features of the game ILE and the state characteristics of a single case. However, it was considered that the explanatory effects matrix could not provide us a dynamic view of these causes and effects and thus, four case dynamic matrices were employed for displaying how the features of the game cause a change in the values of the motivational states of a single case. Even though the case dynamic matrices help us understand the change in the values of the motivational states caused by the features of the game ILE, it is difficult to see from the matrices the variables involved in the context and the relationships among them. As a result, a causal network was employed to present these variables and their relationships in a more coherent picture. As a result of the case study analysis, we came up with the revised version of the causal model of motivation and the summary of the major findings for each individual case.

Apart from analysing 6 cases individually, we also looked across these cases for the patterns of motivation in order to create a more general motivation model. Thus, all 6 cases were divided into two groups according to their report regarding motivation in learning: ‘learners’ (the cases who were motivated to learn) and ‘non-learners’ (the cases who were not motivated to learn) and a revised causal model of motivation was developed for each group. The models focus on the interaction among the motivational states which were considered to contribute to motivation in learning, and what was done or supposed to be done with the features of the game ILE to create positive impacts on these motivational states. It is known from the models that attention and relevance were the motivational states that were likely to be affected directly by the features of the game ILE and thus, they were termed as the ‘initial states’ whereas cognitive curiosity, effort and confidence were the motivational states that were likely to be affected after and, hence, they were termed as the ‘consecutive states’. Nevertheless, the order among the consecutive states is not clear from the models. Furthermore, we had the impression that the long-term relevance was likely to be the most important motivational state in the game-based learning context followed by the short-term relevance. However, we could not tell how much each of these motivational states (and also the other motivational states) contributed to motivation in learning in terms of quantity. Apart from the revised version of the motivation model, 8 general key points were drawn from looking across the six cases (see section 8.5 for more details). 11 condition-action rules could also be obtained from the in-depth analysis of the six cases and the comparison between cases. These condition-action rules were created in the hope that they could offer useful guidelines for the development of the computer program that implements the revised version of the motivation model.

All this considered, we believe that we have discovered the following findings:

- what the model of learners’ motivation looks like and the way it changes in the context of an educational game
- how the method of case study analysis could be potentially applied to research in the area of Artificial Intelligence in Education (AIED)
- how computer games could be used as a learning environment for learning and teaching the concept of ERM in database modelling
- how MoRes could be improved in the aspect of its accuracy in inferring the value of the motivational state based on the key points and the condition-action rules obtained from the analysis of data (this finding was considered to relate to the issue of the design and development of a computer program and thus, instructional designers and computer programmers would play an important role in this)

We also believe that the model, the key points and the condition-action rules represent an encouraging step in the direction of creating game-based intelligent learning environments that can monitor the motivational states that contribute to motivation in learning. However, several improvements could be made in order to improve the efficiency of the model. In the following sections we look at some further reflections regarding the model and also at some further work that are worth pursuing.

## 9.2 Some Further Reflections

Although the qualitative results of the study are encouraging with respect to the plausibility of the model and the findings drawn from the case study analysis, there is no doubt that some aspects of the study should perhaps be dealt with differently if given a second chance. The issues researched in this thesis are complex and involve several intertwined areas which require lots of effort in completing them. Some issues such as the model itself and the methodological decision will be considered.

**Is the motivation model appropriate?**

As mentioned by Porayska-Pomsta (2003)

> "The model often combines the theoretical contributions by other researchers in a somewhat simplified and even naive manner which leaves it open to a considerable amount of criticism." (p.299).

The model presented in this thesis is based on theoretical and empirical evidence and it also involves various variables. Thus, one who prefers a narrower research scope may criticise the model in the aspect of critical examination (e.g. focusing on a small set of variables rather than a wide range of them). However, to my knowledge there is no precedent against which it could be compared except that of de Vicente & Pain (2002). Their model assumes a general instructional domain and a generic student whereas our model applies to a specific context: the educational game context. Furthermore, we believe that it is appropriate to create first a qualitative model and to consider a numeric model as possible further work since we do not know how one is motivated to learn through the use of an educational game. By revealing the process of how one is motivated, we believe that it represents the useful model of each student's motivation during the interaction with the game ILE. Also, the evidence that we got from each student is rich and comes from multiple data sources (pre-questionnaire, post-questionnaire, self-report, observation, webcam), and it was considered that the data is appropriate for an in-depth analysis. The evidence reveals the value of various motivational states at different points in the game interaction and how the features of the game ILE could affect the motivational states of a student. The evidence also exposes the relationships among the motivational states themselves. In addition the strategies for optimising the value of the motivational states were obtained from the evidence. According to the explanation so far, we believe that the model is appropriate with respect to a particular domain and target students; however, if the model is to be applied to different domains and target students, it may be able to be done so with further investigation (e.g. possible features of the ILE in that domain).

**One may consider the design of the model is arbitrary**

It is true that the model, to some extent, is arbitrary, particularly, the preliminary version of the model. As explained in chapter 4, our preliminary model was created on a theoretical and an intuitive basis. Two program prototypes, Alex's Adventure and MoRes, were developed based on this model and thus, the rules used for assigning the game to an individual student and the rules used for making an inference about the value of some motivational states (cognitive curiosity, effort and confidence) may be criticized. However, in my view it is difficult to develop the model which is not arbitrary at all. According to Ogborn (1994), modelling is to create one simplified and predetermined thing (a model) in order to think about another. According to this, it was considered that a model is more or less arbitrary in nature. Nevertheless, the model was created based on the qualitative analysis of the empirical evidence and hence, it was considered that to some degree, the model was developed with a more solid basis.

**Which aspects of the model are supported by the evidence?**

The evidence obtained from the main study (see the details about the study in section 6.4.2) throws light onto the issue which we aimed to investigate at the beginning of this research. As mentioned in chapter 1, we are interested in determining the motivational structure of students during the interaction with the game ILE and making progress in determining the way this might change during the interaction. The evidence we obtained from each student reveals the change in the value of the motivational states during the game interaction. It also exposes the effects of the game features on the motivational states of the student and the relationships among the motivational states. Furthermore, from the evidence the strategies for enhancing the value of the motivational states were obtained as there were several points in the game where the values were dropped/could be improved. However, the evidence may be questioned in terms of how reliable it is.

**Which aspects of the model are not strongly supported by the evidence?**

There are some aspects of the model which are not clear from the evidence. From the evidence we know that relevance is the motivational state that plays an important role in the motivation in learning of a student. However, we cannot specify how important it is in terms of quantity. This is also the case for other motivational states since the analysis was done qualitatively. Furthermore, we know from the evidence that attention and relevance are the motivational states that could be affected directly by the features of the game ILE whereas cognitive curiosity, effort and confidence are the motivational states that were likely to be affected after. The relationship between effort and confidence was considered to exist from the evidence; however, it is not clear whether the relationship between cognitive curiosity and effort exists as in the preliminary model.

**How could the reliability of the data be improved?**

There is no doubt that when people were asked about their emotions, orientations, etc. there was always the danger that their answer might be false or inaccurate (see Oppenheim, 1992, cited in (de Vicente, 2003)) In the area of evaluating emotional/motivational experience, self-report seems to be the least complex and the most common method. According to Alsmeyer et al. (2007), there are three main methods for collecting self-reports: free response approach, the dimensional emotion response approach and the discrete emotion response approach. These methods seem to suffer from some limitations. Consider the discrete emotion approach as an example, this approach requires students to describe their feelings using a given scale (e.g. a five-point Likert scale) and the approach suffers from various drawbacks. For instance, given a limited scale, this may restrict what the student can report their feelings which results in a loss of data. Some studies require the students to report their feelings in descriptive words which can be applied to their study; however, the comparison across studies cannot be done using these results and it can lead to a false report of the feelings in order to please the researchers. However, it is stated in their work that one contribution from their study to the AIED community is to encourage the investigation into the use of multiple data sources when inferring about the emotional state of a learner.

In our study several kinds of research instruments were used (pre-questionnaire, post-questionnaire, self-report, observational notes and webcam) in order to obtain the motivational data from the participants since we considered that using various research instruments could provide more accurate data and at the same time, a way of dealing with the reliability issue. However, in my view it is impossible to prove that the data represents the motivational states of the participant perfectly as mentioned earlier and also, there may be an issue with the participants with regards to 'saving face' if they feel that their report may make them look different from what they think the researcher expects or may decrease their self-esteem.

**Is the method of case study analysis a good choice for applying to research in the AIED community?**

It is known from the literature (e.g. Yin, 1994; Miles & Huberman, 1994) that the case study analysis is a method that can be used for investigating an empirical topic by studying in depth a single case example of the phenomena – the case can be an individual person, an event or an institution. As suggested by Yin (1994, p. 6-9), the method is suitable for answering "how" and "why" research questions because such questions deal with operational links that need to be traced over time, rather than frequencies or incidences. It is also a preferred strategy for examining contemporary events, especially when the relevant behaviours cannot be manipulated. According to the literature explained so far, it was considered that the method is of use for dealing with research that is complex in nature (e.g. research in emotions and motivation) as the method can provide a thick and vivid description (as can be seen from this thesis). The method also focuses more on the process of a phenomenon; thus, it was considered that the method can contribute to research that requires an in-depth insight into a process of what is going on in a phenomenon. However, the method may be criticised by researchers who prefer to see statistical data as they may consider the data provide more solid conclusions/findings. This seems to be true, but as written in section 6.5, the statistical analysis often comes after the qualitative analysis; that is the qualitative method (e.g. case study analysis) can be used to expose the process of a phenomenon and the quantitative method (e.g. hypothesis testing) can be applied later in order to focus on a more specific issue. The main message which we intend to propose concerning the use of case study analysis is that the method is sensible and powerful to be used for analysing the data; however, the use of the method still depends on the aim and the nature of the research itself.

**Can the way of analysis used in this research be extended to apply with other research in the AIED community?**

As for this issue, it is important to, first of all, acknowledge that the nature of each research is different and thus, the method which is suitable to use in a particular research may not be suitable for another, or if it is considered to be suitable, the method may need to be adjusted in order to make it fit with the nature of that research. Based on this, it was considered that the way of analysis used in this research may be applied to other research that is similar in nature. For example, research aiming to create a computer program that aids learning may consider applying the analysis used in this research to get feedback from students about the efficiency of the program, how it may improve and so on (similar to what was done in this research using different kinds of matrices (e.g. effects matrix, case dynamic matrices)). Research attempting to expose the relationships among different emotions (either positive or negative) that occur in a learning environment may also be benefit from applying the way of analysis used in this research (similar way of analysis may be done with some adjustments e.g. some tables may be dropped if they are not related).

## 9.3 Further Work

The models (one for the 'learners' group and another one for the 'non-learners' group) presented in this thesis are intended to be a stepping stone in modelling motivation in a specific context and thus, one may consider the models not to be able to clarify some aspects. In this section a list of some further improvements and extensions that could be carried out based on this research is presented.

**1. Extending the qualitative model by further components relating to motivation.**

As shown in chapter 8, the revised models consist of two parts: the trait characteristics – ILE features part and the ILE features – state characteristics part. In particular, the models involve 9 motivational variables (4 trait variables and 5 state variables). However, it seems that further investigation into the components which may contribute to motivation can be done in order to extend the model. For example, according to the definition and the aspects of empathy appeared in Paiva et al.'s (2004) work, one may find empathy is likely to be the state that contributes to motivation in the context of an educational game. Another example is the investigation into the plausible outside factors. As can be seen from the models, two outside factors were included in the models (experience and during-session performance) as from the evidence they were considered to play a role in the confidence level of the participant. However, there may be some other factors that can affect on the other motivational states and thus, one may choose to examine further these plausible factors in order to enhance the models.

**2. Further investigation in applying the model to other contexts.**

Our models were developed with respect to the educational game context; however, it seems that further investigation into the issue of applying the model to other contexts can be done as another way to make use of the models. For instance, one may examine whether the model can be applied to other contexts such as on-line learning and MILE (Multimedia Interactive Learning Environments).

**3. Transforming the qualitative model into the numerical/computational model.**

To my knowledge no numerical model that deals with motivation in the educational game context is known to exist except that of Conati and her colleagues (Conati & Zhou, 2002; Conati & Maclaren, 2005). They devised a probabilistic model of student affect which was used by pedagogical agents to generate tailored interventions aiming to stimulate the student to learn better from the educational game (they claimed that several studies (e.g. Klawe, 2000) indicate that while educational games are usually successful in increasing student engagement, they often fail in triggering learning); it seems that while her primary aim is to model affect, the (hidden) aim is still to motivate students to learn. However, their model focuses on dealing with different emotional states (e.g. joy, distress) rather than motivational states; in addition, they stated in one of their papers (Conati & Maclaren, 2005) that they experienced some difficulties when building a user model of affect as there existed some issues which were unclear (e.g. the existing knowledge of emotional reactions during system interaction, the difficulty of observing key variables). It was considered that our qualitative model of motivation could provide this information and hence, our methodology used for creating such a model can contribute to the investigation of those issues. Similarly, their approach was considered to contribute to further work that could be carried out based on this research. That is, further investigation can be done in order to change our qualitative models into the numerical/computational models (similar to Conati's). As can be seen from chapter 8, the revised models are presented in a form of reaction network which shows what reacts with what. The models consist of several paths and thus, it seems to contain several numerical models. One may choose a specific path and develop a particular numerical model of the kind which can be put into a computer and simulated.

**4. Further development of the game ILE: Alex's Adventure.**

Our game ILE can be enhanced in order to be used as an educational game for teaching Entity Relationship Modelling (ERM). The game can be improved by extending the storyline in order to include the other concepts in ERM (e.g. the concept of relationships).

**5. Further development of MoRes.**

MoRes can be improved/used as an example in order to develop a better tool to test the condition-action rules obtained from the study and also, to be a computer program that implements the revised motivation model.

**6. An integration of the game ILE and MoRes.**

As explained in chapter 6, our game ILE was developed separately from MoRes since it was considered that the development can be done rapidly. However, one may feel that there is a drawback in the aspect of software maintenance and thus, may want to combine the two programs together.

## 9.4 Conclusions

The purpose of the research presented in this thesis is to determine a motivational structure for students during their interaction with a game-based learning environment and to make progress in determining the way this may change during interaction. The focus was specifically on investigating the relationship between the features of the game ILE and the motivational characteristics of a student.

By relating the goals of this thesis (as mentioned in section 1.2) with the results of the study and evaluation, the main contribution of this research, as explained in chapter 1 (section 1.3), has been fourfold:

1. To develop a model of learners' motivation that is novel in the following aspects: (a) it demonstrates the existing relationships between the features of an ILE and the motivational characteristics of learners (b) it relies on both specific theories of motivation in instructional design and empirical evidence (c) it is created using a qualitative method in education – case study analysis in particular (d) it can be applied to a specific context (the educational game context) and it may be extended to apply within other context.
2. To obtain, from the results of the analysis, the condition-action rules. The benefits of the rules are that they represent the findings of the study in a symbolic manner which was considered to be useful for the implementation of the rules in a computer program. Also, the rules were considered to be of use as a stepping stone into the development of interactive and intelligent learning environments that can empathise with learners.
3. To propose a method of case study analysis as a potential alternative for AIED (Artificial Intelligence in Education) community. The method helps us in getting an in-depth understanding of how a learner is motivated through the use of an ILE developed in a specific context using multiple sources of evidence. Thus, the model of learners' motivation developed based on this technique was considered to be more valid and reliable.
4. To design and develop two separate computer-based research instruments that implemented the preliminary version of motivation model. These two instruments are: the game prototype – Alex's Adventure and the prototype – MoRes. Alex's Adventure was created as a learning environment that could strongly impact students' motivation and it aimed at teaching some abstract concepts in ERM domain. MoRes was built as a computer program in which its main functions were to get the values of trait characteristics from a student and to assign the version of the game that is likely to suit him/her, to obtain the values of initial state variables from a student after he/she finished playing the game and to infer the value of the other state variables as they chronologically appeared in the model, and to infer his/her motivation towards the game at the end of the interaction session. These two prototypes may be further extended (e.g. the game may include other concepts in ERM, the revised model of motivation may be implemented into a computer program, etc.)

It is true that our model of learners' motivation contains some limitations. Despite its limitations, we considered the model throws light into the process of how students are motivated to learn which we believe is a promising step into creating a learning environment that cares about learners.

# Appendix A

# Interfaces of Computer Based Research Instruments

This appendix presents the interfaces of computer based research instruments which were developed for using in the field study: the interfaces of the game prototype – Alex's Adventure 1.0, Alex's Adventure 2.0 and Alex's Adventure 6.0 and the interfaces of the computer program – MoRes. As mentioned in chapter 5, the scenes used in different versions of the game are very similar and thus, only the different scenes appeared in Alex's Adventure 2.0 and Alex's Adventure 6.0 will be displayed since Alex's Adventure 2.0 contains some branching scenes whereas Alex's Adventure 6.0 consists of some adjusted scenes.

# A.1 Interfaces of Alex's Adventure 1.0


Figure A.1.1: The 'Opening' scene

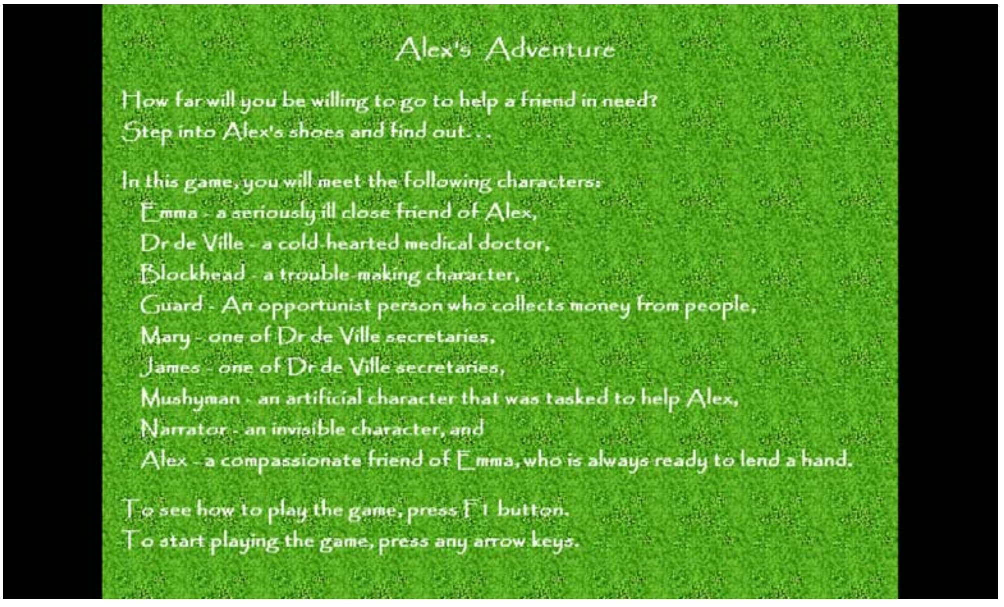


Figure A.1.2: The 'Invitation' scene


Figure A.1.3:   The ‘Emma’s House’ scene

Figure A.1.4:   The ‘Meet Emma’ scene

Figure A.1.5: The ‘In the Forest’ scene


Figure A.1.6: The ‘Dr de Ville’s Empire’ scene

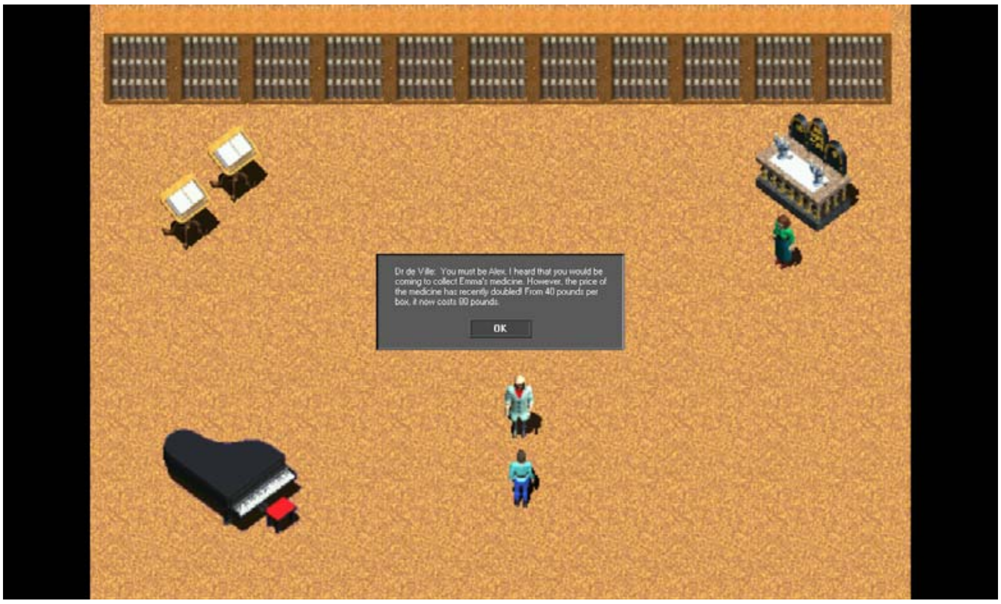


Figure A.1.7: The ‘Meet Dr de Ville #1’ scene


Figure A.1.8: The ‘First Task’ scene


Figure A.1.9: The ‘Meet Mushyman #1’ scene

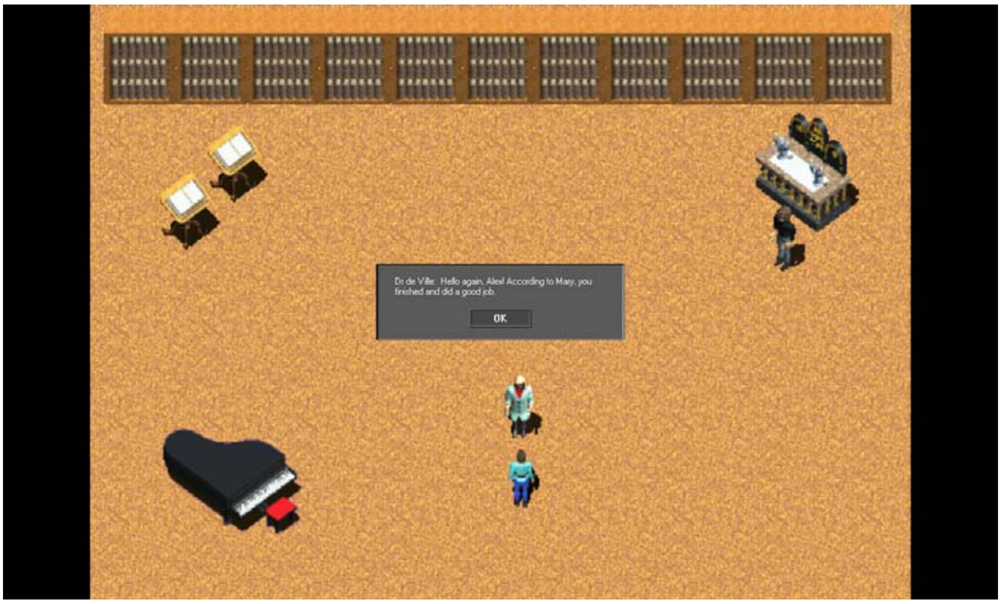


Figure A.1.10: The ‘Meet Dr de Ville #2’ scene


Figure A.1.11:   The ‘Second Task’ scene


Figure A.1.12:   The ‘Meet Mushyman #2’ scene

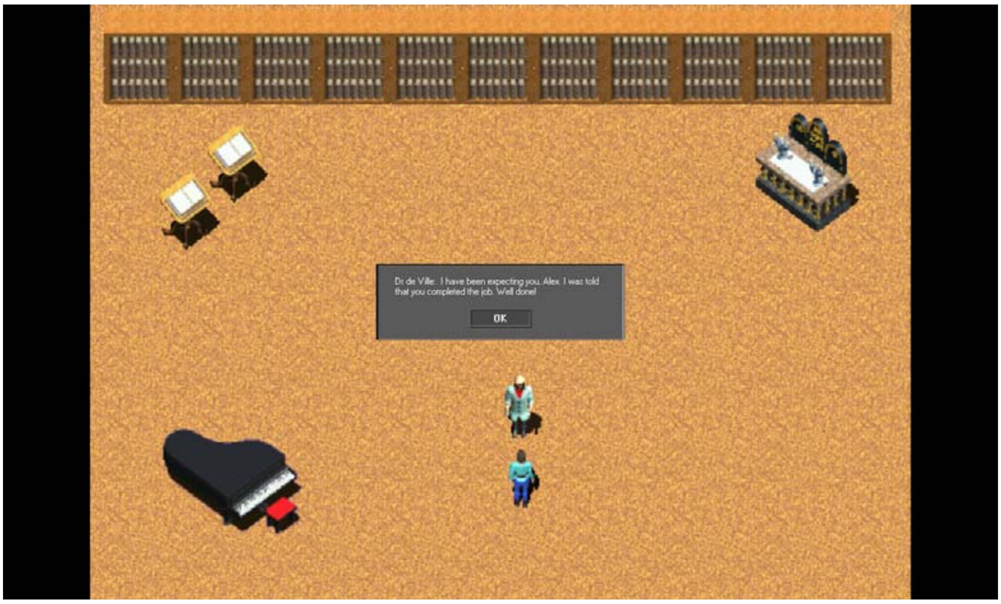


Figure A.1.13: The ‘Meet Dr de Ville #3’ scene


Figure A.1.14: The ‘Back to Emma’s House’ scene

Figure A.1.15: The ‘Back to Emma’ scene


Figure A.1.16: The ‘Ending’ scene

# A.2 The Branching Scenes of Alex's Adventure 2.0


Figure A.2.1: The 'Dark Forest' scene

Figure A.2.2: The 'Dark Forest' scene (cont.)

# A.3 The Adjusted Scenes of Alex's Adventure 6.0


Figure A.3.1: The 'First Task' scene


Figure A.3.2: The 'First Task' scene (cont.)


Figure A.3.3: The 'First Task' scene (cont.)


Figure A.3.4: The 'Second Task' scene


Figure A.3.5: The ‘Second Task’ scene (cont.)


Figure A.3.6: The ‘Second Task’ scene (cont.)

# A.4 Interfaces of MoRes (User Part)

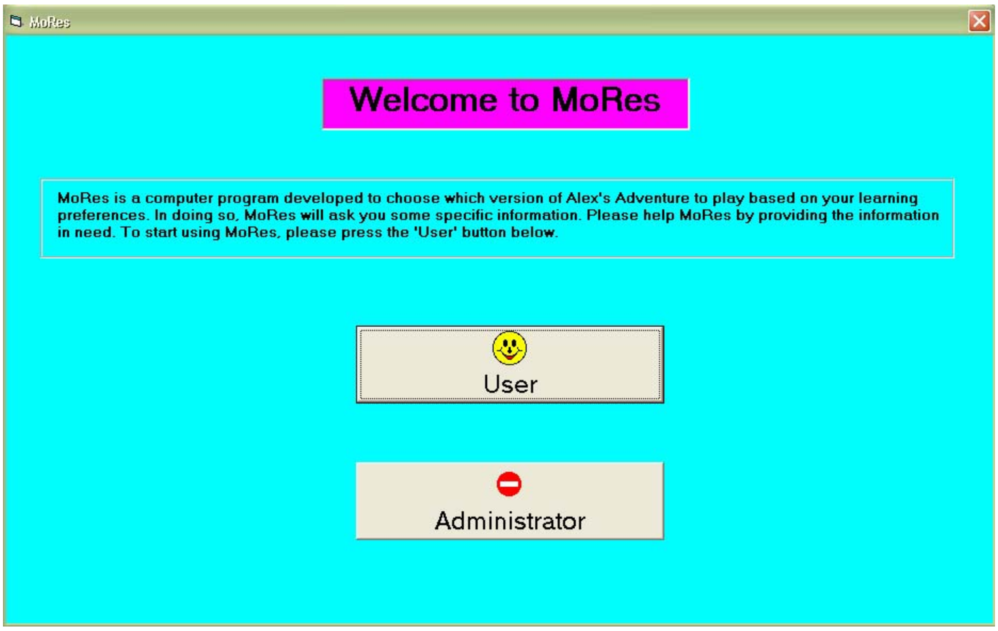


Figure A.4.1: The first screen

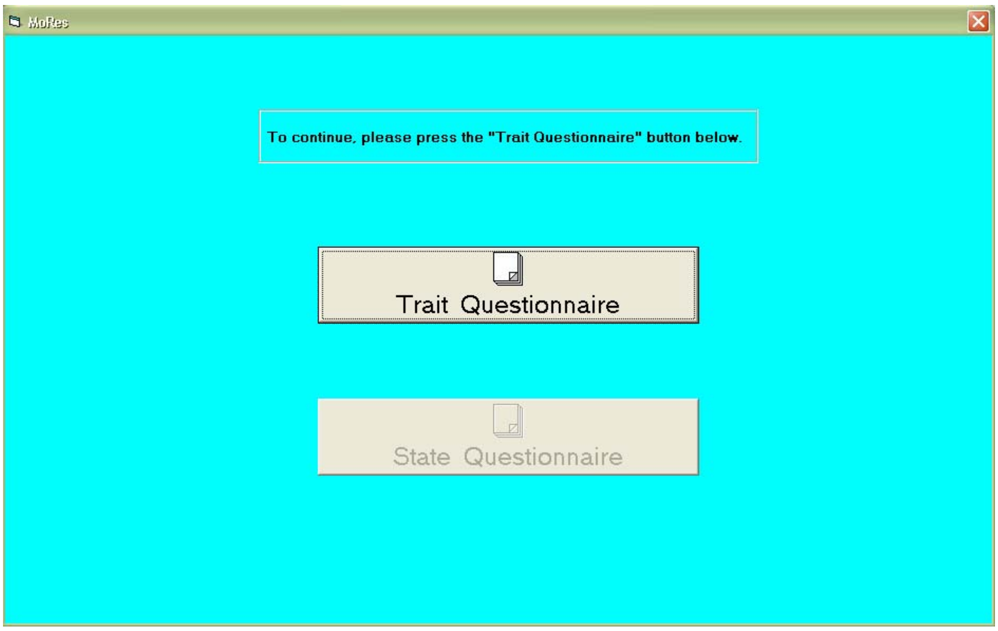


Figure A.4.2: The second screen

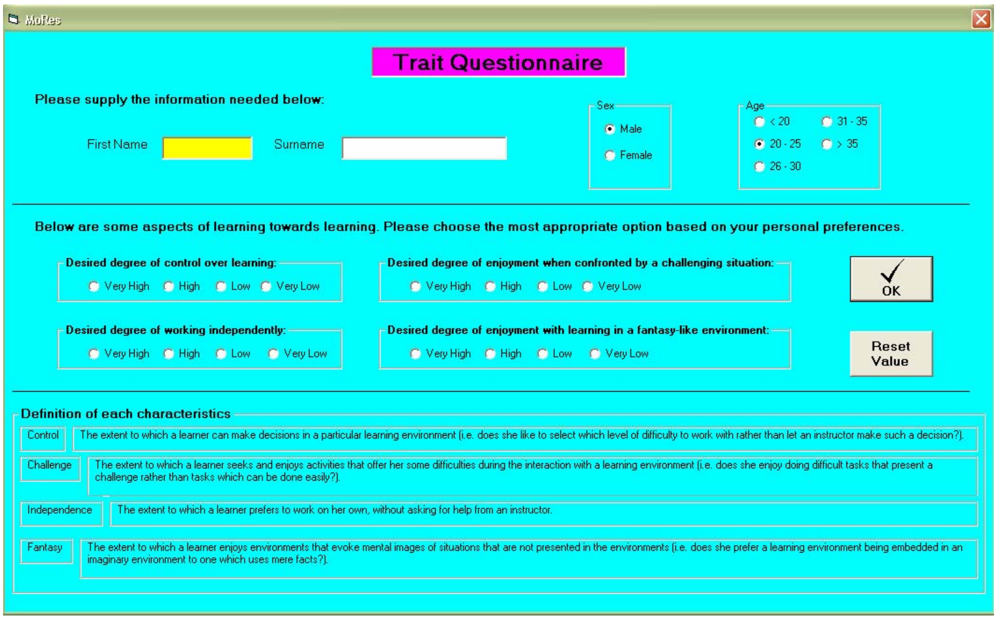


Figure A.4.3: The third screen (trait questionnaire)


Figure A.4.4: The first response screen (after a user fill in the trait questionnaire)

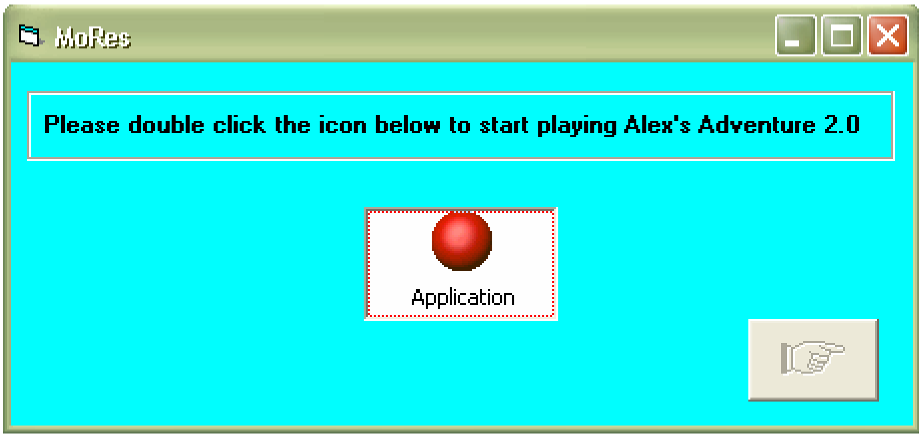


Figure A.4.5: The second response screen (after a user fill in the trait questionnaire)

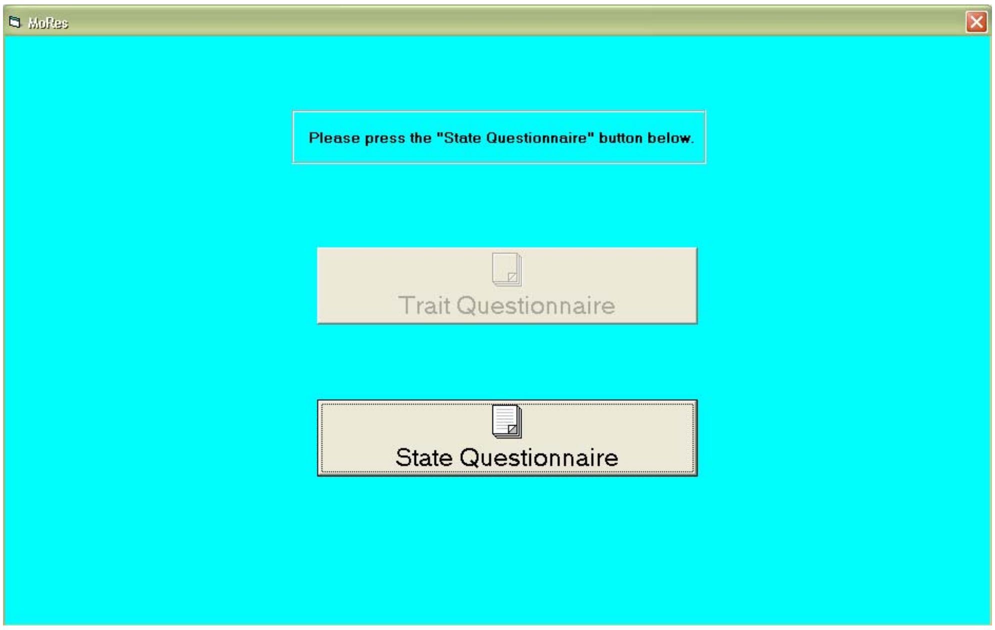


Figure A.4.6: The fourth screen

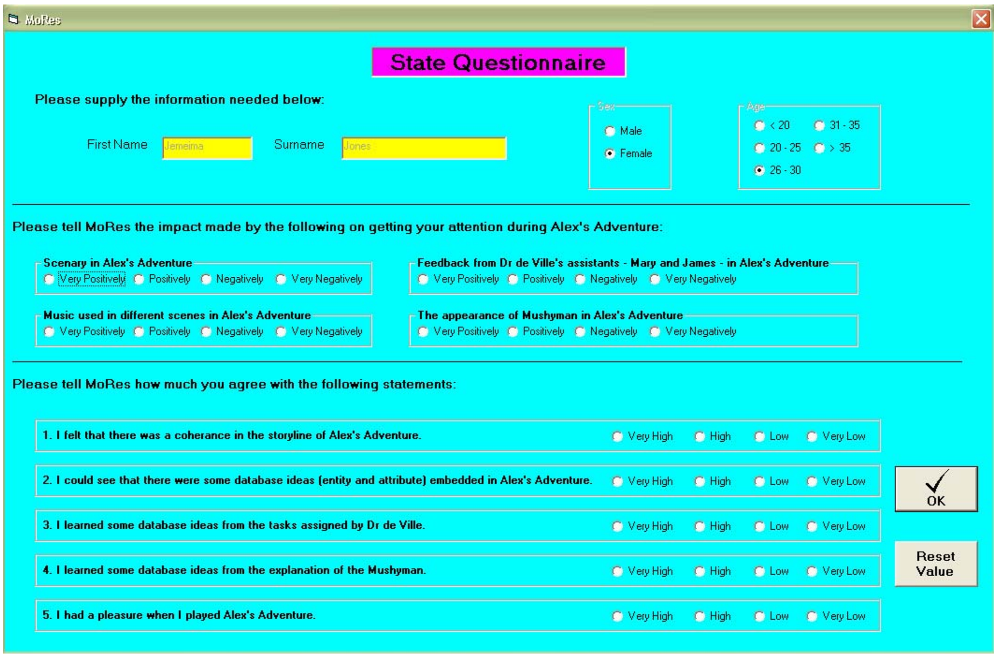


Figure A.4.7: The fifth screen (state questionnaire)

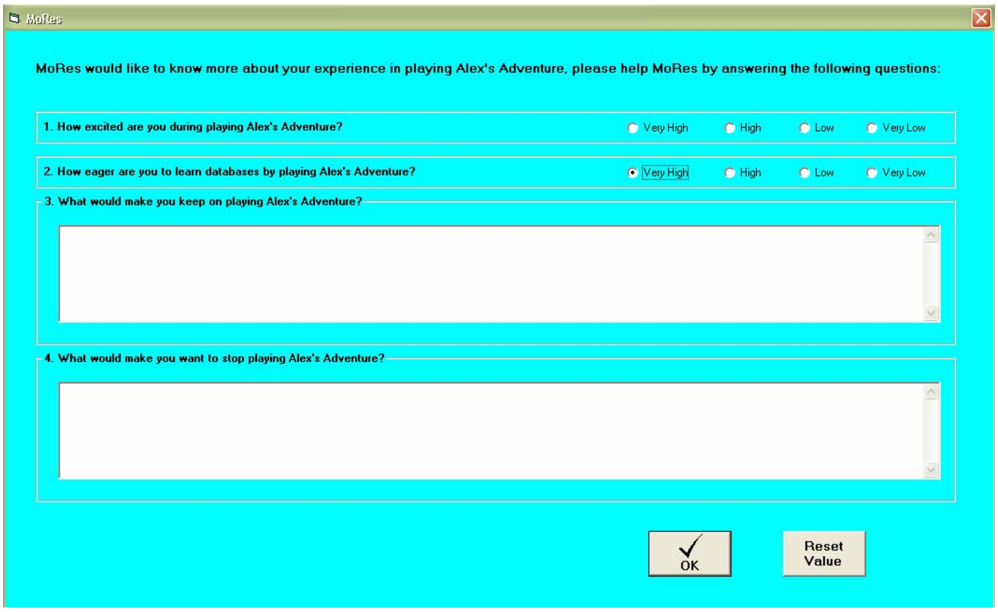


Figure A.4.8: The sixth screen (general comment)

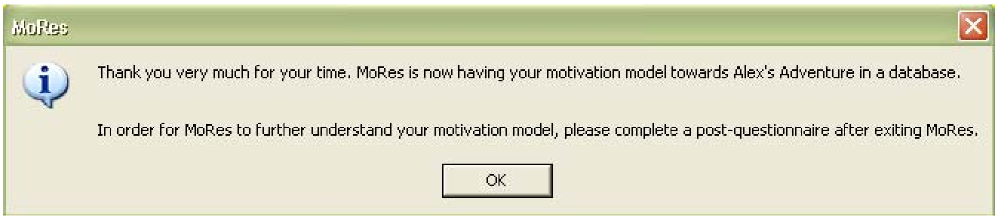


Figure A.4.9: The third response screen (after a user fill in the state questionnaire and provide general comments towards Alex’s Adventure)

# A.5 Interfaces of MoRes (Administrator Part)

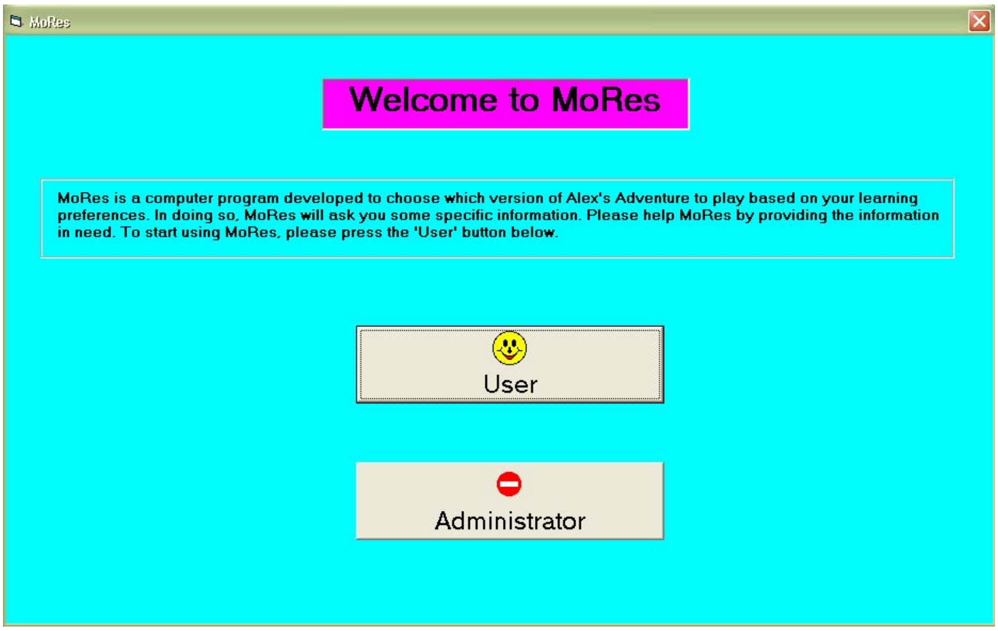


Figure A.5.1: The first screen

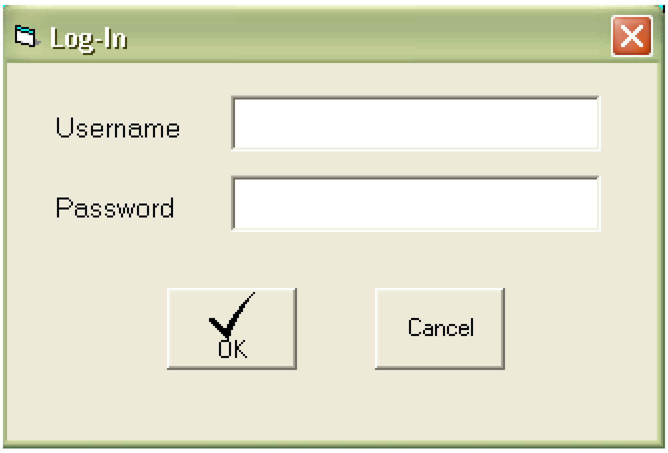


Figure A.5.2: The first response screen (after the 'Administrator' button was pressed)

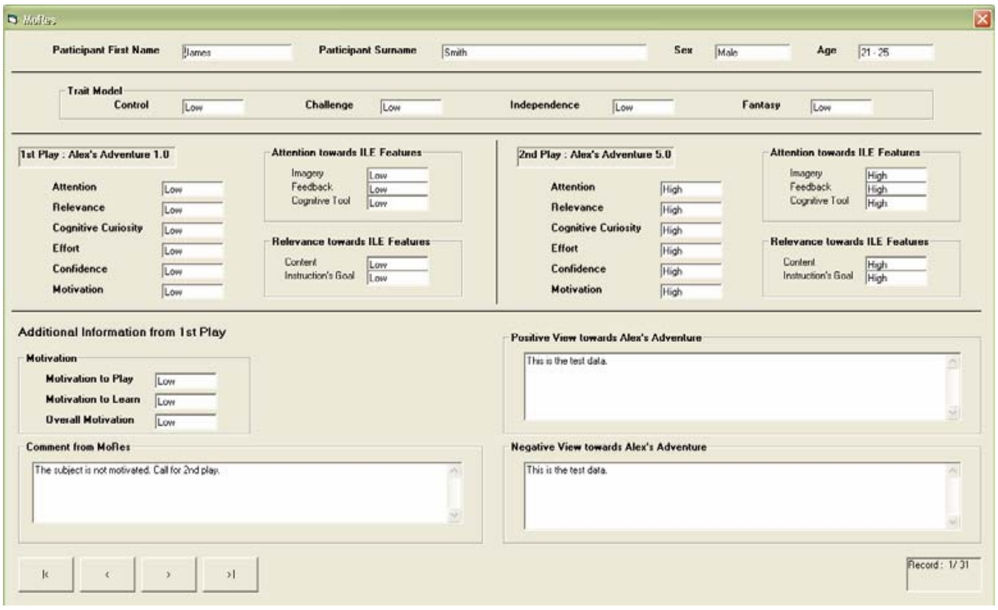


Figure A.5.3: The second screen

# Appendix B

# Materials of Study

This appendix contains the following materials in relation to the field study of the research: a plain language statement, a consent form, an instruction sheet for the study, pre-questionnaire, post-questionnaire, snapshots of some scenes in the game – Alex's Adventure (both the original and the adjusted versions) and a retrospective self-report. The first two documents are an attempt in satisfying the demands of ethical considerations. The instruction sheet for the study provides the details of how to complete the study which can be regarded as the document used for preparing the participants to take part in the study. The other four documents were used for gathering the required data from the participants.

B.1 A Plain Language Statement
B.2 A Consent Form
B.3 An Instruction Sheet for the Study
B.4 Pre-questionnaire
B.5 Post-questionnaire
B.6 Snapshots of Some Scenes in the game – Alex's Adventure (the original version)
B.7 Snapshots of Some Scenes in the game – Alex's Adventure (the adjusted version)
B.8 A Retrospective Self-report

# B.1 A Plain Language Statement

***Study Title and Research Details***

1. **Department/Centre:** SCRE Centre

2. **Project Title:** Towards Motivation Modelling within a Computer Game Based Learning Environment: An Empirical Study

3. **Researcher:**

| Title & Surname | First Name | Phone | Email |
|---|---|---|---|
| Miss Methaneethorn | Jutima | 0141 3308546 | jutimam@educ.gla.ac.uk |

4. **Supervisor(s):**

| Title & Surname | First Name | Phone | Email |
|---|---|---|---|
| Prof Brna | Paul | 0141 3301917 | paul.brna@scre.ac.uk |
| Dr Elliot | Dely | 0141 3302467 | dely.elliot@scre.ac.uk |

5. **Course of Research:** PhD

***Invitation to a Research Study***

You are being invited to take part in a research study. Before you decide it is important for you to understand the purpose of the study and what it will involve. Please take time to read the following information carefully. If there is anything that is not clear or if you would like more information, please do not hesitate to ask us. Take time to decide whether or not you wish to take part.

Thank you for reading this.

***The purpose of the study***

Recent research points to the notion that motivation is a crucial factor when creating Intelligent Learning Environments (ILEs). However, there are no explicit models of how learners are motivated while using an ILE. Hence, we have chosen to research the construction of a learner's motivational structure and this initiates the aim of our research: to create a predictive model of motivation for an ILE in the context of an educational game and narrative. This context attracted our attention since from the literature, the association of motivation, educational games and narrative seems to be strong. We believe that such a model will be potentially of great benefit when creating tutoring systems that take into account the motivational aspects of the learner. This research study will take approximately 4 years to complete.

***Chosen Subjects***

You have been asked to participate in this research because you are a student in the Department of Computing Science, University of Glasgow. Since the subjects will be asked to play an educational game – Alex's Adventure – that teaches databases, students in computing science with some background or no background in databases are ideal. Approximately 20-25 subjects are expected to participate in the study.

Participation is voluntary. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

***Procedures of the study***

In the study you will be asked to use a computer program-MoRes and play an educational game- Alex's Adventure. A webcam will be installed on the computer along with its software to capture your interactions during a session with the game. The aim of using the webcam is to obtain qualitative data (e.g. gesture, facial expression) about you when playing the game. This data will be used to support the data from other sources (e.g. questionnaires and self-report) in the study. The data from the webcam will be stored as a computer file and it will be deleted from the computer immediately after the data analysis is finished. You will also be asked to fill in two questionnaires. One is a pre-questionnaire which you will be given at the beginning of the study. The aim of the pre-questionnaire is to get your general views about computer games. The second one is a post-questionnaire which you will be given after you finish playing Alex's Adventure. The post-questionnaire aims to discover your overall feelings about the game. Finally, you will be asked to complete a retrospective self-report which aims to get some ideas about the way your motivation changes through the session with Alex's Adventure.

The interaction time with the computer program-MoRes is around 10 to 15 minutes whereas the estimated time in playing the educational game-Alex's Adventure-may vary depending on your pace; however, the approximate time is 20-30 minutes. Questionnaires are designed in such a way that they can be completed within 15 to 20 minutes whilst the retrospective self-report will take 15-25 minutes to finish. To sum up, the study will last between 1 to 1 and 1/2 hours.

***Confidentiality and Data Handling***

All information collected during the course of the research will be kept strictly confidential in locked filing cabinets and computer files. Access to those computer files is available by named researchers with password only. Once the research has been completed, paper copies containing the data will be shredded and the computer files saved in the computers will be deleted.

***Results of the Research Study***

Results will be made available as part of my Thesis and in potential publications (e.g. conference papers, journal articles). In the thesis and any publications arising from the research, you will be given a pseudonym. The results will be made available to you on request.

***Sponsor/Funding Body***

The researcher receives full funding for her PhD studies from the Royal Thai Government.

The project has been reviewed by the Faculty of Education Ethics Committee. Should you require further information, please contact us at the details provided below.

| Title & Surname | First Name | Phone | Email |
|---|---|---|---|
| Miss Methaneethorn | Jutima | 0141 3308546 | jutimam@educ.gla.ac.uk |
| Prof Brna | Paul | 0141 3301917 | paul.brna@scre.ac.uk |
| Dr Elliot | Dely | 0141 3302467 | dely.elliot@scre.ac.uk |

If you have any concerns regarding the conduct of the research project, you can contact the Faculty of Education Ethics officer-Dr George Head at G.Head@educ.gla.ac.uk.

# B.2 A Consent Form

**Title of Project:** Towards Motivation Modelling within a Computer Game Based Learning Environment: An Empirical Study

**Name of Researcher:** Jutima Methaneethorn

1. I understand that the project is for PhD research.

2. I confirm that I have read and understood the Plain Language Statement for the above study and have had the opportunity to ask questions.

3. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

4. I understand that all information I provide during and after the study will be kept strictly confidential.

5. I understand that in any publication arising from the research, information will be provided in such a way that I cannot be identified.

6. I agree/do not agree (delete as appropriate) to take part in the above study.

| | | |
|---|---|---|
| ____________________ | ________ | ____________________ |
| Name of Participant | Date | Signature |
| ____________________ | ________ | ____________________ |
| Researcher | Date | Signature |

## B.3 An Instruction Sheet for the Study

This instruction sheet provides the details of how to complete the study. There are ten steps that you will need to follow:

1. Please have a look through the package of materials particularly in relation to the introduction to the game.

2. Please fill in the pre-questionnaire and return it.

3. Please start using the computer software – MoRes – by pressing 'User' button followed by 'Trait Questionnaire' button.

4. Please provide information about your general attitude to learning.

5. You will be directed by MoRes to Alex's Adventure, please start playing the game.

   **Note: There will be a dialog box appear stating about the software, please press 'Run'. <u>DO NOT PRESS 'Cancel'</u>**

6. When you finish playing Alex's Adventure, please continue using the computer software – MoRes – again.

7. When you finish using MoRes, please fill in the post-questionnaire and return it.

8. When you finish filling in the post-questionnaire, please start doing the self-report by looking at each snapshot and reporting your feelings at that time.

**Note: When filling in the post questionnaire and doing the self-report, <u>PLEASE DO NOT</u> referred back to the questions in which you already answered.**

## Introduction to Alex's Adventure

Alex's Adventure is a prototype of a role playing adventure game designed to teach two concepts in database modeling.

In the game, you will take the role of Alex.

Alex is a compassionate friend of Emma. Emma has been suffering from an illness for a long time. One day, she ran out of her medicine and she was too weak to buy the medicine herself. She then asked Alex to get the medicine from a cold-hearted medical doctor, Dr de Ville, and the adventure begins….

In this game, **Alex will need to come into contact with other characters to get information**.

The following are **controls** used in Alex's Adventure:

**Alex's movements:**

| | | |
|---|---|---|
| Left Arrow | - | Move Alex to the left |
| Right Arrow | - | Move Alex to the right |
| Up Arrow | - | Move Alex upward |
| Down Arrow | - | Move Alex downward |

**Alex coming into contact with other characters:**

| | | |
|---|---|---|
| Mouse (Left Click) | - | To close the pop-up message box |
| | - | To make a choice when the game provides several options |

**Doing the given tasks:**

| | | |
|---|---|---|
| Mouse (Left Click) | - | To **select** the desired object |
| Mouse (Right Click) | - | To **view information** about an object |

**Help:**

| | | |
|---|---|---|
| F1 | - | To see all controls used in the game (This button can be pressed at any time whilst playing Alex's Adventure.) |

# B.4 Pre-questionnaire

**Player's Profile**

1. Sex: ○ Male ○ Female
2. Age: ○ <20 ○ 20-25 ○ 26-30 ○ 31-35 ○ >35

**Section 1** About database modelling

1. Have you read books about database modelling before?
   ○ Yes ○ No

2. Have you been on database modelling courses before?
   ○ Yes ○ No

3. Have you ever done any database modelling yourself?
   ○ Yes ○ No

4. Have you ever created a database yourself?
   ○ Yes ○ No (Please go to Question 6.)

5. Have you ever used any database software before?
   ○ Yes, I have used______________________________________________.
   ○ Yes, but I cannot remember.
   ○ No

6. How confident are you at database modelling?
   ○ Very Confident – I am an expert in this area.
   ○ Confident – I have a reasonably good knowledge of this area.
   ○ Fairly Confident – I have some knowledge of this area.
   ○ Not Confident – I have no significant knowledge of this area.

**Section 2** About computer games

1. Have you ever played computer games?
   ○ Yes ○ No (Please go to Question 6.)

2. What computer games have you played before?

3. Do you enjoy playing computer games?
   ○ Yes ○ No (If the answer is 'No', please give your reason(s).)

4. What do you like most about computer games? (Please rank these features with 1 indicating the aspect you like most.)

   ☐ Storyline ☐ Characters ☐ Tasks in games

   ☐ Graphics ☐ Music

   ☐ Other…………………………………………………………….

5. What kind of computer games do you enjoy playing? (You can make more than one choice.)
   - ○ Adventure game (A type of game in which a player has to focus more on problem-solving rather than combat and statistics e.g. Zork Nemesis)
   - ○ Strategy game (A type of game in which a player's decision making skills having a high significance in determining the outcome e.g. Simcity, chess)
   - ○ Puzzle game (A type of game in which emphasises puzzle solving e.g. Tetris)
   - ○ Shooting game (A type of game in which a player has control over a character who is usually armed with a firearm that can be freely aimed)
   - ○ Role-Playing game (A type of game in which a player assume the role of a character and collaboratively create a story e.g. Dungeons & Dragons)

6. Have you heard of role-playing games (RPG) before?

   ○ Yes ○ No (Please go to Question 8.)

7. Do you like playing role-playing games?

   ○ Yes ○ No ○ I don't know.

   (If the answer is 'No', please give your reason(s).)

8. What do you think are the positive points of computer games in general?

9. What do you think are the negative points of computer games in general?

10. What do you think are the positive points of learning through computer games?

11. What do you think are the negative points of learning through computer games?

12. If you were to play a computer game, would you like to play with somebody? If so, why?

# B.5 Post-questionnaire

The questions in this questionnaire were developed in order to assess the value of the participants' state characteristics (motivational states) in relation to the game in general. The questionnaire consists of two parts. The first part contains the questions relating to the state characteristics whereas the second part asks for the general comments in relation to the game. The questions appeared in the first part were categorised into six sections and the purpose of the questions for each section is explained below:

- The questions developed in the first section aim at obtaining the data regarding the overall feeling towards the game (e.g. the student's attention paid to the game in general, the student's curiosity towards the game in general); the data were used to support the data obtained from the other sections of the questionnaire.
- The questions developed in the second section aim at obtaining the data regarding the overall state characteristics towards the feature – imagery, in the game (e.g. the student's attention paid to the imagery used in the game, the student's curiosity towards the imagery used in the game).
- The questions developed in the third section aim at obtaining the data regarding the overall state characteristics in relation to the feature – content, of the game (e.g. the student's attention paid to the content of the game, the student's curiosity towards the content of the game).
- The questions developed in the fourth section aim at obtaining the data regarding the overall state characteristics towards the feature – feedback, given during the tasks in the game (e.g. the student's attention paid to the feedback given during the tasks, the student's curiosity towards the feedback given during the tasks).
- The questions developed in the fifth section aim at obtaining the data regarding the overall motivation towards the game (both motivation to play and motivation to learn).
- The questions developed in the sixth section aim at obtaining further information regarding the features of the game which attracted the student the most and the reason behind the student's enjoyment of the game.
- The questions appeared in the second part were created aiming to get the general comments on the game. The first and the second questions ask for what the student likes and what he/she dislikes when playing the game, respectively. The third question whether the student would be interested to play it if there was an extended version of the game (the question aims at checking whether the game

was satisfying to the student in general even though there might be some features in the game which was not satisfying to him/her). The last question asks for suggestions from the student on how the game could be improved.

**Instruction:** The questions in this questionnaire relate to your feelings whilst playing Alex's Adventure. Please try to think back to **how you felt at the time you played the game**.

## Part 1 State Characteristics

### Section 1 Immersion

| | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. I was interested in Alex's Adventure. | ○ | ○ | ○ | ○ |
| 2. The story of Alex's Adventure made me wish Alex would get the medicines to help Emma. | ○ | ○ | ○ | ○ |
| 3. I wanted to find out how the story would end. | ○ | ○ | ○ | ○ |
| 4. I was keen to accomplish Alex's tasks and finish the game. | ○ | ○ | ○ | ○ |
| 5. If there was a game similar to Alex's Adventure, I would be able to play it well. | ○ | ○ | ○ | ○ |

### Section 2 Imagination/Creativity

| | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. The scenes in Alex's Adventure were nicely laid out. | ○ | ○ | ○ | ○ |
| 2. The music used in different scenes in Alex's Adventure was appropriate. | ○ | ○ | ○ | ○ |
| 3. After finishing with one scene, I wondered what the next scene of Alex's Adventure would be. | ○ | ○ | ○ | ○ |
| 4. I tried to explore the scenes and had contacts with other characters in Alex's Adventure. | ○ | ○ | ○ | ○ |
| 5. As each scene passed by, I felt more confident in exploring Alex's Adventure. | ○ | ○ | ○ | ○ |

## Section 3 Content

| | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. I learned some database ideas (entity and attribute) from the tasks in Alex's Adventure. | ○ | ○ | ○ | ○ |
| 2. I learned some database ideas (entity and attribute) from the explanation of the Mushyman. | ○ | ○ | ○ | ○ |
| 3. I found that the story of Alex's Adventure was enjoyable. | ○ | ○ | ○ | ○ |
| 4. I felt that the storyline of Alex's Adventure is coherent. | ○ | ○ | ○ | ○ |
| 5. I could see that there were some database ideas (entity and attribute) included in Alex's Adventure. | ○ | ○ | ○ | ○ |
| 6. After finishing with the first task, I felt curious to know what the next task would be. | ○ | ○ | ○ | ○ |
| 7. I tried to understand the database ideas reflected by the tasks in Alex's Adventure. | ○ | ○ | ○ | ○ |
| 8. If there were more similar tasks, I would be able to play the game well. | ○ | ○ | ○ | ○ |

## Section 4 Feedback

| | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. The feedback from Mary and James about the tasks which I did for Dr de Ville gained my attention. | ○ | ○ | ○ | ○ |
| 2. I was interested in receiving some feedback from Mary and James after doing the tasks. | ○ | ○ | ○ | ○ |
| 3. I was keen to try and finish the tasks after receiving some feedback from Mary and James. | ○ | ○ | ○ | ○ |
| 4. If I did something wrong, I tried to figure out how to make it work. | ○ | ○ | ○ | ○ |
| 5. I felt that I could do the next task correctly after receiving some feedback from Mary and James. | ○ | ○ | ○ | ○ |
| 6. The immediate appearance of Mushyman gained my attention. | ○ | ○ | ○ | ○ |
| 7. I wondered what Mushyman would say next. | ○ | ○ | ○ | ○ |
| 8. The explanation from Mushyman stimulated me to think about the work I did. | ○ | ○ | ○ | ○ |
| 9. After carefully listening to Mushy Man, I felt that I could do the next tasks better. | ○ | ○ | ○ | ○ |

**Section 5 Satisfaction/Motivation**

| | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. I was happy to learn by playing Alex’s Adventure. | ○ | ○ | ○ | ○ |
| 2. I was happy to play Alex’s Adventure. | ○ | ○ | ○ | ○ |

**Section 6 Further Information**

1. What do you like most in Alex’s Adventure? (Please rank these features with 1 indicating the aspect you like most.)

☐ Story ☐ Tasks ☐ Graphics ☐ Music ☐ Mushyman ☐ Dr. de Ville’s assistants (Mary & James)

2. Do you enjoy playing Alex’s Adventure?

○ Yes, because (If you had more than 1 reason, please rank these reasons with 1 indicating the most important one.)
- ☐ I want to learn the database concept.
- ☐ I want to learn the database concept in a new environment.
- ☐ I want to have fun.
- ☐ Others ________________________________________________

○ No

**Part 2 General Comments**

1. What would make you keep on playing Alex's Adventure?

2. What would make you stop playing Alex's Adventure?

3. If there was an extended version of Alex's Adventure in the future, would you like to play it?

○ Yes ○ No

(If the answer is 'No', please specify the reason(s).)

4. Do you have any suggestions as to what would help improve Alex's Adventure?

# B.6 Snapshots of Some Scenes in the game – Alex's Adventure (the original version)

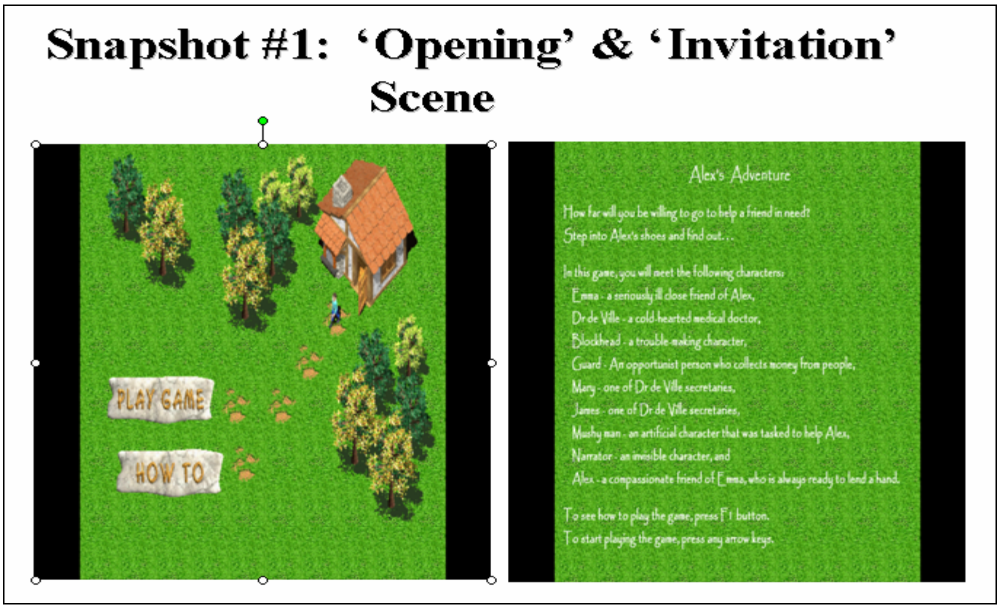


Figure B.6.1: The first snapshot


Figure B.6.2: The second snapshot

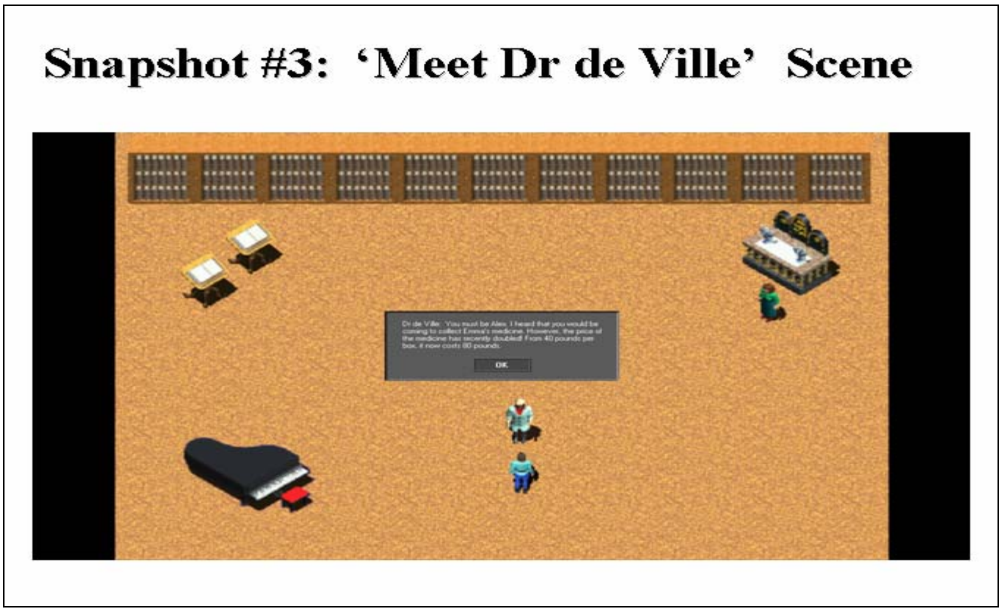


Figure B.6.3: The third snapshot


Figure B.6.4: The fourth snapshot


Figure B.6.5: The fifth snapshot

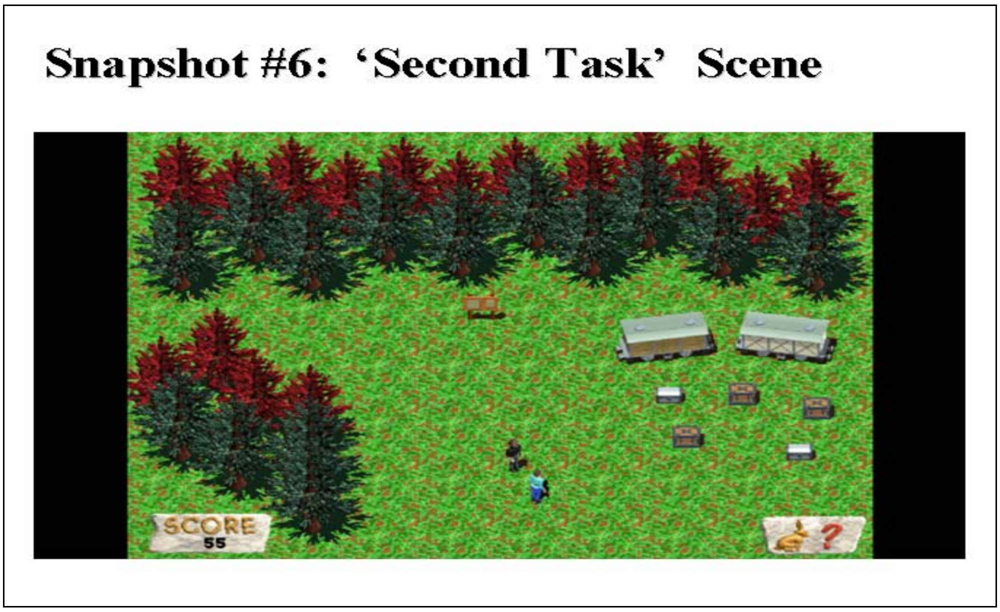


Figure B.6.6: The sixth snapshot


Figure B.6.7: The seventh snapshot

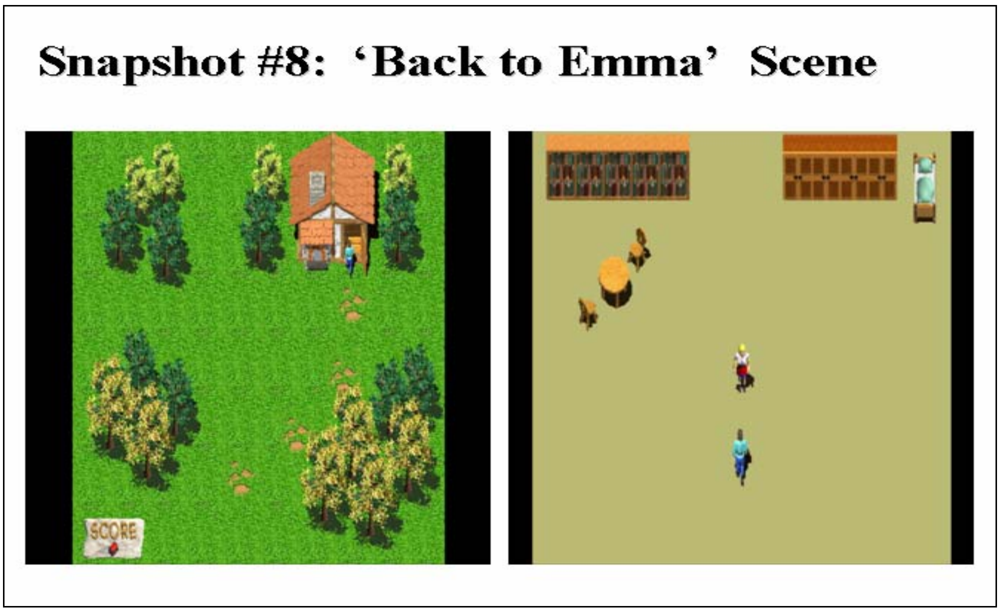


Figure B.6.8: The eighth snapshot

# B.7 Snapshots of Some Scenes in the game – Alex's Adventure (the adjusted version)


Figure B.7.1: The first snapshot


Figure B.7.2: The second snapshot

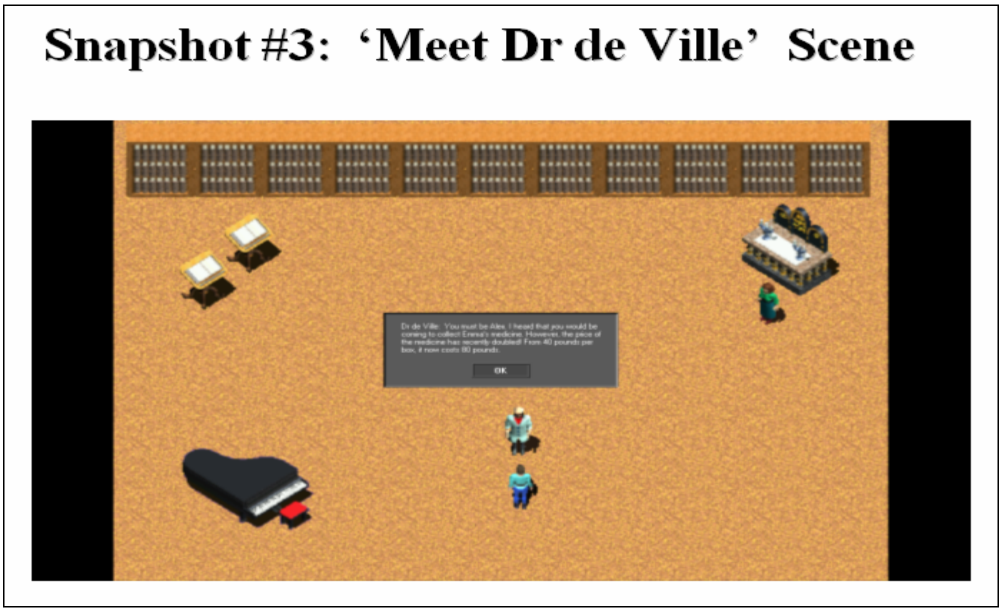


Figure B.7.3: The third snapshot

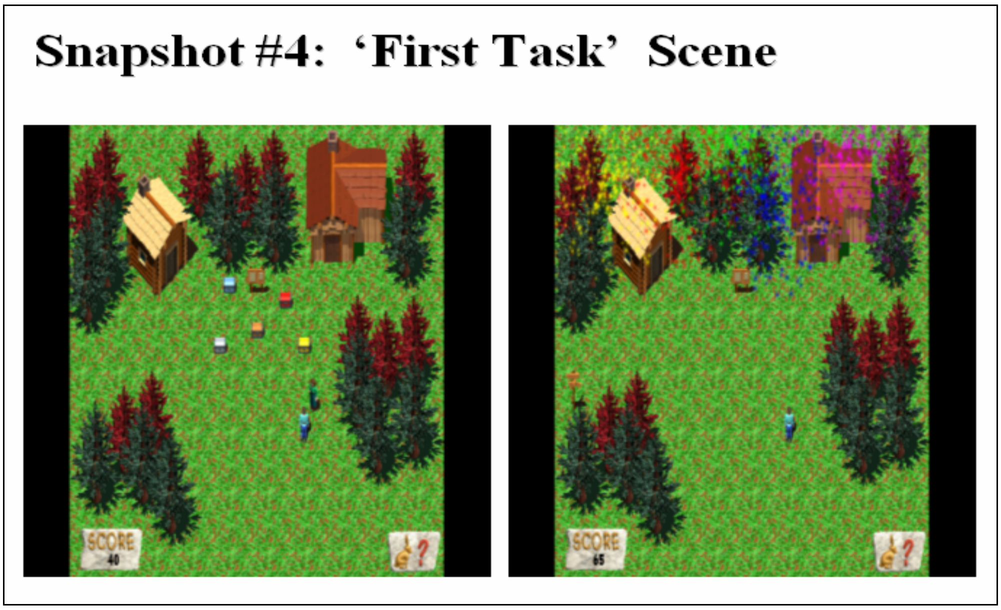


Figure B.7.4: The fourth snapshot


Figure B.7.5: The fifth snapshot

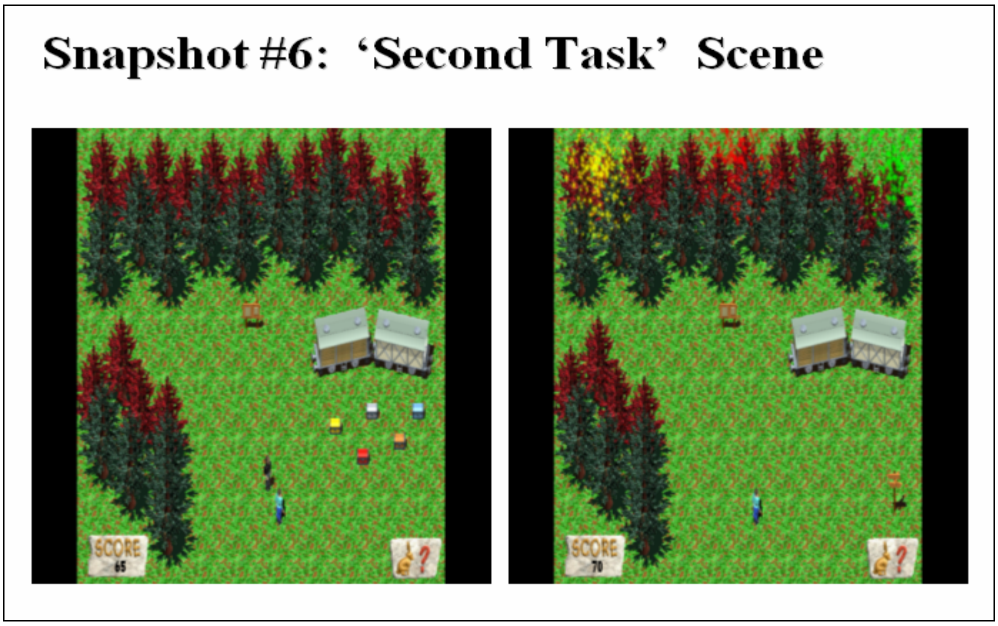


Figure B.7.6: The sixth snapshot


Figure B.7.7: The seventh snapshot


Figure B.7.8: The eighth snapshot

# B.8 A Retrospective Self-report

The questions in this self-report were developed in order to get the value of different state characteristics (motivational states) during interaction with the game. The game was divided into eight stages and is represented by eight snapshots. The questions created for each snapshot relate to different motivational states occur at the specific points in the game. The number of questions in each snapshot is different as it was considered that not every feature was presented in every scene. That is, the number of the questions depends on the features presented in a specific scene. For example, in snapshot 3, the features: feedback and cognitive tool, are not presented (these two features first appear in snapshots 4 and 5, respectively.). Thus, there is no question created for measuring the attention paid to these two features unlike in snapshots 4 and 5 for which a question was created aiming to measure the attention paid to the features – feedback and cognitive tool, respectively. The relationships between the questions and the motivational states aiming to be measured (the italic font appeared in the bracket after each question) are presented in each snapshot.

However, it was acknowledged that there might be some ambiguities for the participants since when developing a questionnaire, it is not appropriate to use the exact word to refer to what is aimed to measure (e.g. if we intended to measure the level of effort used by the participant, it was considered not to be appropriate to use this statement "I used a high level of effort to search for all the mushrooms in the forest."; rather, a statement considered to be more suitable was "I was trying to search for all the mushrooms in the forest." as it was considered to show the degree of the effort used.). As a result, there were possibilities in which the participants might misinterpret the meaning of the statement; however, experienced researchers were consulted during the development of the retrospective self-report. Additionally, the material was piloted before using it for the main study and the results showed that the self-report worked with the students who participated in the pilot study. Based on this, it was considered that the self-report used in this research worked satisfactorily.

**Instruction:** The questions in this self-report relate to **your feelings whilst playing Alex's Adventure with regard to a particular scene as shown in the snapshots**. Please try to think back to how you felt at the time you played the game. To report your feelings, a scale with five values (Very Low, Low, Not Applicable, High, Very High) was created. Please circle the answer which represents your feelings.

**<u>Snapshots #1:</u>** **'Opening' & 'Invitation' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. I wanted to know what database ideas I could learn from Alex's Adventure. *(relevance-goal: support learning,content)* | | | | | |
| 2. I felt interested to play Alex's Adventure when I saw its opening scene. *(attention-imagery)* | | | | | |
| 3. I was interested to play Alex's Adventure when I was invited to take Alex's role. *(relevance-goal: provide fun)* | | | | | |
| 4. I felt curious to start playing Alex's Adventure after having a glimpse of all the characters in Alex's Adventure *(cognitive curiosity)* | | | | | |
| 5. I tried to figure out the story of Alex's Adventure when I was getting to know each character. *(effort)* | | | | | |
| 6. I was ready to play Alex's Adventure by the time I finished with the 'Invitation' scene. *(confidence)* | | | | | |

**<u>Snapshots #2:</u>** **'In the Forest' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. I noticed something interesting in the 'forest' scene. *(attention-imagery)* | | | | | |
| 2. I could see that finding all the mushrooms in the forest was the first obstacle I had to overcome in Alex's Adventure. *(relevance-content)* | | | | | |
| 3. I felt challenged to find all the mushrooms in the forest. *(relevance-goal: provide fun)* | | | | | |
| 4. After talking to Blockhead, I was keen to find all the mushrooms in the forest. *(cognitive curiosity)* | | | | | |
| 5. I was trying to search for all the mushrooms in the forest. *(effort)* | | | | | |
| 6. I felt that I could find all the mushrooms in the forest if I looked carefully. *(confidence)* | | | | | |
| 7. I wondered what database ideas I could learn from the activity (finding all the mushrooms). *(relevance-goal: support learning)* | | | | | |

**<u>Snapshots #3:</u>** **'Meet Dr de Ville' Scene**

Very Low | Low | Not Applicable | High | Very High

1. I found myself standing in a room with two other persons who drew my attention to the scene. *(attention-imagery)*
2. When having a conversation with Dr de Ville, I tried to understand what he wanted me to do. *(effort)*
3. As time passed by, I felt more confident in having a conversation with Dr de Ville. *(confidence)*
4. I was curious to know what Dr de Ville would ask me to do. *(cognitive curiosity)*
5. I suspected that the tasks given me by Dr de Ville might be relevant to learning some database ideas. *(relevance-goal: support learning)*
6. I was interested to do the tasks after the conversation with Dr. de Ville was finished. *(relevance-goal: provide fun)*

**<u>Snapshots #4:</u>** **'First Task' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. I saw several interesting things in the place to which Mary took me. *(attention-imagery)* | | | | | |
| 2. I felt challenged to move all the crates into the right storehouse. *(relevance-goal: provide fun)* | | | | | |
| 3. I could see that the database ideas of entity and attribute were hidden in the task. *(relevance-goal: support learning, content)* | | | | | |
| 4. The feedback from Mary about the task gained my attention. *(attention-feedback)* | | | | | |
| 5. I wondered what feedback I would get from Mary after each move. *(cognitive curiosity)* | | | | | |
| 6. I was keen to try and finish this task so that I could move on. *(effort)* | | | | | |
| 7. After finishing the first task, I felt more confident to move on to the next task. *(confidence)* | | | | | |

**<u>Snapshots #5:</u>** **'Meet Mushyman #1' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. The immediate appearance of Mushyman gained my attention. *(attention-imagery)* | | | | | |
| 2. The explanation from Mushyman gained my attention. *(attention-cognitive tool)* | | | | | |
| 3. I wondered what Mushyman would say next. *(cognitive curiosity)* | | | | | |
| 4. The explanation from Mushyman stimulated me to think about the work I did. *(effort)* | | | | | |
| 5. I was happy that the database ideas embedded in the task were made clearer by the explanation from Mushyman. *(relevance-goal: support learning, provide fun)* | | | | | |
| 6. I could see that the task which I just did represented the database ideas of entity and attribute. *(relevance-content)* | | | | | |
| 7. After listening to Mushyman, I felt more confident in doing the next task. *(confidence)* | | | | | |

**<u>Snapshots #6:</u>** **'Second Task' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. I saw several interesting things in the place to which James took me. *(attention-imagery)* | | | | | |
| 2. I felt challenged to move all crates into the right wagon. *(relevance-goal: provide fun)* | | | | | |
| 3. I could see that the database ideas of entity and attribute were hidden in the task. *(relevance-goal: support learning)* | | | | | |
| 4. The feedback from James about the task gained my attention. *(attention-feedback)* | | | | | |
| 5. I wondered what feedback I would get from James after each move. *(cognitive curiosity)* | | | | | |
| 6. I was keen to try and finish this task so that I could move on. *(effort)* | | | | | |
| 7. After finishing the second task, I felt more confident to move on to the next task. *(confidence)* | | | | | |

**<u>Snapshots #7:</u>** **'Meet Mushyman #2' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. The immediate appearance of Mushyman gained my attention. *(attention-imagery)* | | | | | |
| 2. The explanation from Mushyman gained my attention. *(attention-cognitive tool)* | | | | | |
| 3. I wondered what Mushyman would say next. *(cognitive curiosity)* | | | | | |
| 4. The explanation from Mushyman stimulated me to think about the work I did. *(effort)* | | | | | |
| 5. I was happy that the database ideas embedded in the task were made clearer by the explanation from Mushyman. *(relevance-goal: support learning, provide fun)* | | | | | |
| 6. I could see that the task which I just did represented the database ideas of entity and attribute. *(relevance-content)* | | | | | |
| 7. After listening to Mushyman, I felt more confident in doing the next task. *(confidence)* | | | | | |

**<u>Snapshots #8:</u>** **'Back to Emma' Scene**

| | Very Low | Low | Not Applicable | High | Very High |
|---|---|---|---|---|---|
| 1. Emma's house and the surroundings were nicely laid out. *(attention-imagery)* | | | | | |
| 2. I felt that I tried to complete the tasks given me by Dr de Ville to bring Emma her medicine. *(effort)* | | | | | |
| 3. I wondered what Emma would say after I told my story and gave her the medicine. *(cognitive curiosity)* | | | | | |
| 4. After I gave Emma her medicine, I felt I had succeeded. *(confidence)* | | | | | |
| 5. I felt that there was a coherent storyline in Alex's Adventure. *(relevance-content)* | | | | | |
| 6. I found that I learned some database ideas through the tasks in Alex's Adventure. *(relevance-goal: support learning)* | | | | | |
| 7. It was a pleasure to play Alex's Adventure. *(relevance-goal: provide fun)* | | | | | |

# Appendix C

# The Analysis of Case Study 2

This appendix presents the analysis of case study 2 (case E10). The analysis was done in a similar fashion compared to the other two cases (case study 1 and case study 6) appeared in chapter 7.

## C.1 Background of Case Study 2

The participant is a male gender whose age is below 20 years old. He is a British student and is doing his first degree in computing science. He has no significant knowledge in database modelling, but had experience in creating a database using database software – Microsoft Access. He enjoys playing computer games and has played several kinds of game e.g. role-playing game, strategy game, etc. The participant was asked to provide the data about some of his trait characteristics in a learning environment at the start of the session with MoRes. The trait characteristics of the participant are shown in Table C.1.

Based on his trait characteristics, MoRes assigned him to play Alex's Adventure 3.0[1].

| Control | Challenge | Independence | Fantasy |
|---|---|---|---|
| Low | High | Low | High |

Table C.1: Trait characteristics of case study 2

## C.2 Representations for Describing the Motivation of Case Study 2

### C.2.1 Event Listing of Motivational State

Table C.2 is a table of event listing which was created based on the data reported through the use of a retrospective self-report.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Attention | Imagery | VH | N/A | H | H | VH | N/A | VH | H |
| | Feedback | AS | AS | AS | N/A | AS | H | AS | AS |
| | Cognitive Tool | AS | AS | AS | AS | VH | AS | VH | AS |
| Relevance | Content | H | H | VH | H | VH | VH | VH | VH |
| | Goal: Support Learning | H | H | VH | H | VH | VH | VH | H |
| | Goal: Provide Fun | VH | H | VH | H | VH | H | VH | VH |
| Cognitive Curiosity | | H | H | H | H | VH | H | H | H |
| Effort | | H | VH | VH | H | H | H | VH | H |
| Confidence | | VH | VH | H | VH | VH | VH | VH | VH |

Legend:
VL = Very Low
L = Low
N/A = Not Applicable
H = High
VH = Very High
AS = Absent feature from the scene

Table C.2: Event listing of motivational state of case study 2

1 The specifications of Alex's Adventure 3.0 were described in chapter 5 (section 5.3.1.4).

According to the data shown in the table and our observational notes, the participant seemed to pay attention to the beginning scenes (stared at the scenes all the time; read the introduction to all characters in the ‘Invitation’ scene carefully) and looked curious to start playing the game (clicked the button ‘Play Game’ immediately). When the participant was presented with the ‘In the Forest’ scene where the character – Blockhead was introduced, he seemed to focus on the conversation between this character and the main character (Alex). And, when he was asked to do an activity – finding all mushrooms in the forest – in order to progress to the next scene, he looked curious and made an effort in finishing it (looked over the screen **(:G1)**). After he finished doing the activity and saw the scene was changing, he looked satisfied **(:F1)**. When the participant was presented with the next scene where the other two characters – Dr de Ville and Mary were introduced, his attention was likely to be drawn by their appearances. Furthermore, he seemed to be interested in a conversation between Alex and these characters (seemed to think along **(:G2)** and clicked the button to close the conversation dialogs quicker as time passing **(:G3)**). However, it looked like he felt slightly unsure in the beginning when he was not able to move the main character (Alex), but seemed to be relieved when seeing the other character (Dr de Ville) moving towards Alex instead. In the subsequent scene (the ‘First Task’ scene), the participant was likely to be attracted by objects and dialog boxes describing the scenario of the task and how to do it. He seemed to be highly concentrated when doing the task (checked the information kept in each chest before choosing which one he was going to move **(:G4)** and some chests were checked several times **(:G5)**). The participant finished the task with the highest score and looked satisfied **(:F1)**. In the ‘Meet Mushyman #1’ scene the participant seemed to be attracted by the appearance of the character - Mushyman and its explanation about the knowledge embedded in the task (looked alert **(:F2)**). Also, he seemed to concentrate on the explanation **(:G2)** and looked keen to see the next explanation dialog **(:G3)**. In the following two scenes (the ‘Second Task’ scene and the ‘Meet Mushyman #2’ scene) where the participant was asked to do the second task and was presented with the explanation about the task, his responses were similar to when he did the first task and met Mushyman for the first time except that the degree of his feelings was likely to decrease (looked relax **(:F3)**). However, the participant seemed to feel attentive to the game once again in the last scene in which the main character was brought back to the place where the whole story began. He also looked curious about what was going to happen in this scene (moved the main character to Emma’s house without bothering to wander around the scene **(:G6)**). When the game was finished, the participant seemed to be happy (**(:F1)**).

## C.2.2 Plot of Motivational State

Three plots of motivational states were developed: the plot of attention which was measured against three features – imagery, feedback and cognitive tool, the plot of relevance which was measured against two features – instructional goals (support learning and provide fun) and content, and the plot of three motivational states – cognitive curiosity, effort and confidence.

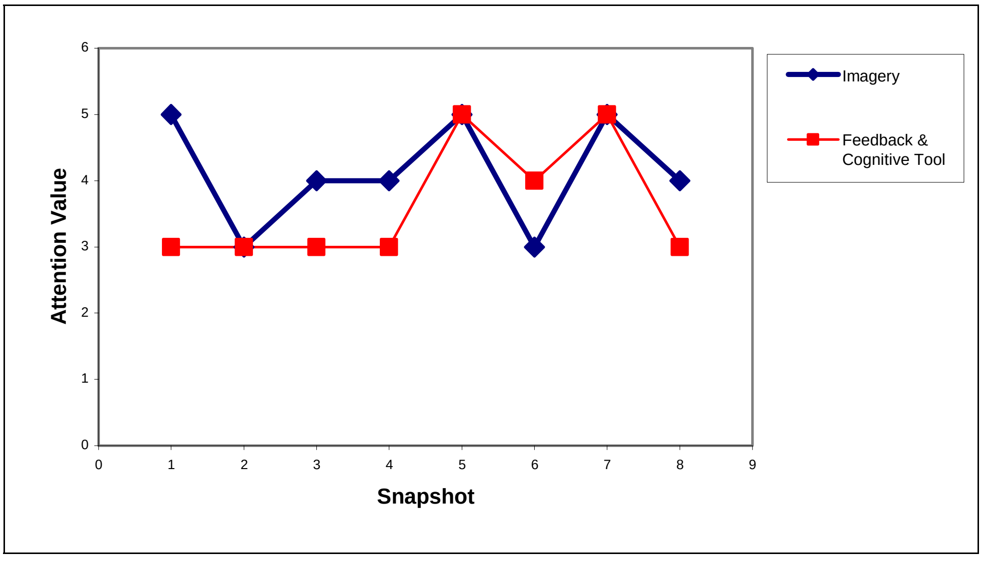


Figure C.1: Attention value towards three features of the game during interaction

Figure C.1 shows the values of the participant's attention towards three features of the game: imagery, feedback and cognitive tool, during interaction with the game. It can be seen from the figure that, generally, the participant's attention paid to the imagery used in the game fluctuates between a high (Attention Value = 4) and a very high level (Attention Value = 5). However, there were some points in the game where the participant was not able to report his attention level (Attention Value = 3); these points are represented by snapshots 2 and 6; the scene captured in snapshot 2 contained hidden objects and thus, when the scene was first presented, he might not be able to spot anything interesting; as for snapshot 6, the scene captured in this snapshot looked similar to the earlier scene (captured in snapshot 4) and hence, the participant might be hesitant to report whether he was attracted to the scene. Also, according to Figure C.1, the participant reported to pay very high attention to the appearance of cognitive tool (in a form of the character named Mushyman) after each task was finished (snapshotd 5 and 7). However, the participant was not able to report his attention paid to the feedback given during the first task, but, he reported to pay high attention when it was given in the second task.

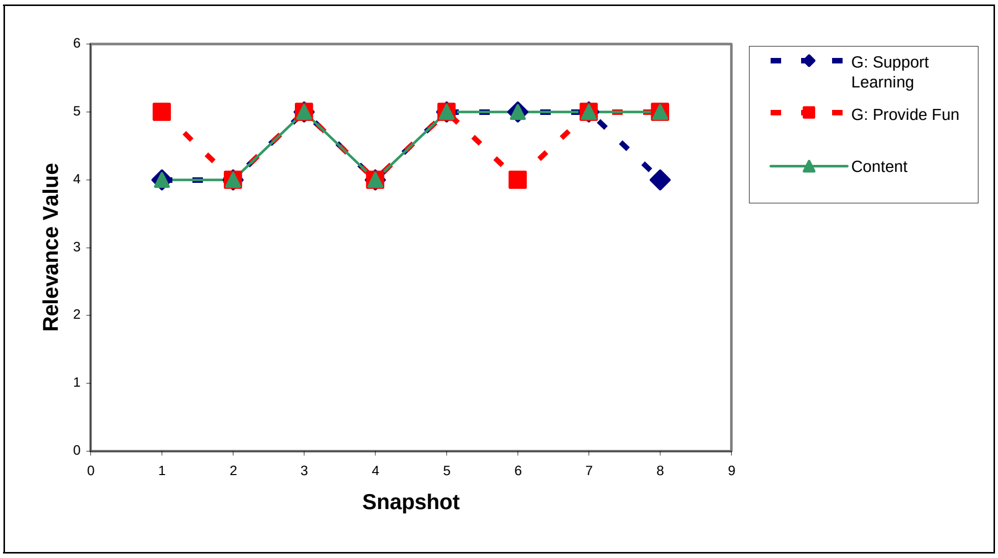


Figure C.2: Relevance value towards two features of the game during interaction

Figure C.2 shows the feelings of relevance of the participant towards two features of the game: instructional goals (support learning and provide fun) and content. According to the figure, it seems that the participant had a high feeling to learn from the start of the game as he reported to feel interested to know what database knowledge he could learn when the first scene of the game was presented (snapshot 1). He also reported to feel wondered how the activity ‘finding all hidden mushrooms in the forest’ was related to learning databases (snapshot 2). In addition, he reported that he suspected that the tasks mentioned by Dr de Ville might involve learning some concepts in databases (snapshot 3). This information was considered to show the high feelings of relevance between the instructional goal – support learning and the goal in learning of the participant. However, his feelings of relevance seemed to drop slightly to a high level in the fourth snapshot where the first task was given; the drop might be because the connection between the knowledge and the task was not obvious to the participant. However, when the cognitive tool was presented afterwards (snapshot 5) to explain the knowledge embedded in the task in a straightforward manner, the participant’s feelings of relevance were reported to increase to a very high level and was preserved at this level through the second task. Similarly, the participant seemed to have the goal in having fun with the game from the beginning as he reported to feel interested in starting playing the Alex’s Adventure from the first scene and this goal was likely to be satisfied throughout the interaction. (According to the self-report, the feelings of relevance fall into the high-value area (Relevance Value = 4 and Relevance Value = 5) during the whole interaction time. Furthermore, it looks like the participant felt that the content of the game could fulfill his goals throughout the interaction as can be seen from the figure, the participant's feelings that the content was relevant to his goals were reported to vary between a high and a very high level (Relevance Value = 4 and Relevance Value = 5).

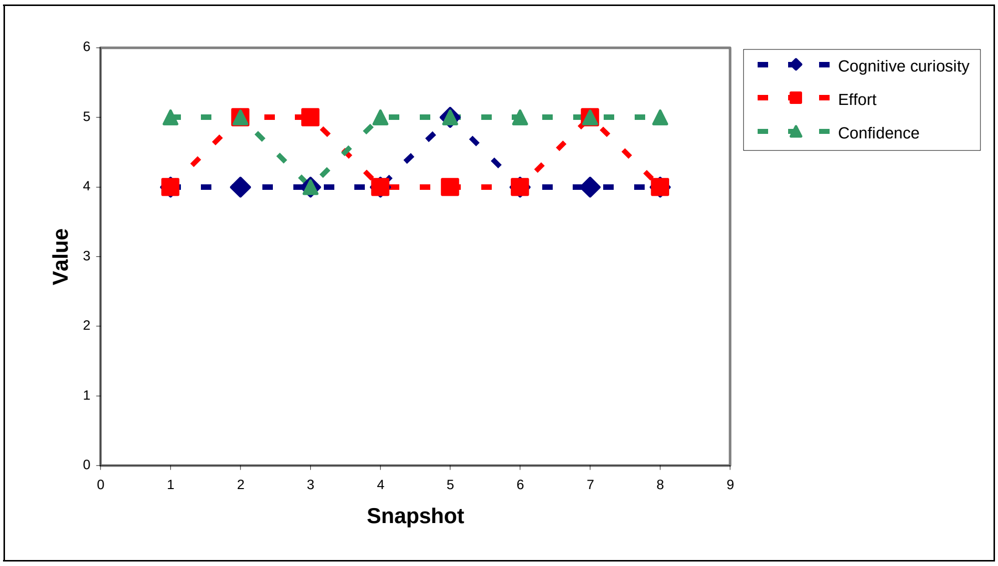


Figure C.3: The value of cognitive curiosity, of effort and of confidence during interaction

Figure C.3 shows the values of the following motivational states during the game interaction: cognitive curiosity, effort and confidence. According to the figure, the participant reported to have a high level of cognitive curiosity throughout the game (Cognitive Curiosity Value = 4 and Cognitive Curiosity Value = 5) and his curiosity was reported to be highest when the cognitive tool was first presented (snapshot 5). Similar to cognitive curiosity, the participant reported to use a high level of effort throughout the interaction with the game and he also reported to feel very confident when playing the game; however, there was a point in the game (snapshot 3) in which his confidence was reported to drop slightly to a high level and it was the point where he was told to that he had to complete some tasks in order to complete the mission.

## C.2.3 Effects Matrix of ILE Features

Table C.3 is a table of effects matrix and it was created in order to describe the effects of game features on the motivational states of participant. The description of the table (below) was created based on existing literature as explained in chapter 4 (section 4.2.3) and evidences (data from post-questionnaire, self-report, observational notes and semi-structured interview).

| ILE Features | Direct Effects + | Direct Effects - | Meta Effects + | Meta Effects - | Side Effects + |
|---|---|---|---|---|---|
| Imagery | Attracted the attention of the participant straight away | Not able to report about the attention in some scenes | Curious about the subsequent scene | | |
| Feedback | Highly attracted the participant's attention regarding his performance when doing the second task in the game | | A high interest in receiving some feedback when doing the second task | | |
| Cognitive Tool | Paid very high attention to the immediate appearance and the explanations about both tasks | | Curious about how the tasks were relevant to databases | | |
| Content | Interested in the storyline of the game and the relevance between the game and the embedded knowledge | | Wanted to find out how the story would end and how the game were relevant to databases | | Widen the participant's view about learning databases in a new environment other than a classroom setting |
| Instructional goals | Wanted to have fun and to learn and the game could fulfil the feelings | | | | |

Sources: Post-questionnaire, retrospective self-report, observational notes and semi-structured interview

Table C.3: Effects matrix of ILE features of case study 2

According to the table, it seems that the use of imagery in the game could catch the participant's attention and it also made him felt curious about the subsequent scenes; however, the participant was not able to report his attention level in some scenes such as the scene presented in snapshot 2 and the scene presented in snapshot 6 (an explanation about these incidents can be found in the description of Figure C.1 in section C.2.2). When the first task was given to the participant, he was also not able to report his attention paid to the feature – feedback which was given during the task; nevertheless, he reported to pay high attention to the feedback given during the second task. The appearance of cognitive tool after each task was finished could attract the attention of the participant and its explanations were reported to be able to stimulate his curiosity about the relevance between the tasks and some concepts in ERM knowledge. As for the content of the game, the participant reported to feel interested in the storyline from the start and was curious about how the story would end and how the tasks in the game were relevant to learning some concepts in databases. After the interaction with the game was finished, the participant reported that he enjoyed learning and playing with the game environment.

# C.3 Representations for Explaining the Motivation of Case Study 2

## C.3.1 Explanatory Effects Matrix

Table C.4 is a table of explanatory effects matrix which was created aiming to display the overall picture of the relationships among trait characteristics, ILE features and state characteristic. Similar to the case studies presented in chapter 7, the explanation of the table was created based on existing literature (see section 4.2.3) and evidences (data from post-questionnaire and self-report) which were considered to support the literature to some degree.

<table>
<tr><th rowspan="2">Trait</th><th rowspan="2">ILE Features</th><th rowspan="2">Game Characteristics</th><th colspan="2">Short-Run Effects<br>(process perspective on state)</th><th colspan="2">Longer-Run Consequences<br>(overall-state perspective)</th></tr>
<tr><th>Direct Effects</th><th>Meta Effects</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td rowspan="2"></td><td>Instructional goal: Support Learning</td><td></td><td>Long-Term Relevance: the goal was likely to exist from the beginning and was achieved throughout the session</td><td rowspan="8">Cognitive curiosity: Maintaining high curiosity throughout the game; a very high level of curiosity in the scene with the first appearance of the cognitive tool<br>Effort: Sustaining high level of effort used in playing the game; a very high level of effort used in the scenes that required more action/thinking from the participant<br>Confidence: Generally, a very high level of confidence was sustained throughout the game</td><td>Long-Term Relevance: H</td><td rowspan="3">Cognitive curiosity: H<br>Effort: H<br>Confidence: VH</td></tr>
<tr><td>Instructional goal: Provide Fun</td><td></td><td>Long-Term Relevance: Another goal of the participant that seemed to exist from the start and was accomplished throughout the session</td><td>Long-Term Relevance: H</td></tr>
<tr><td rowspan="2">Control</td><td>Content</td><td>Cannot choose the storehouse/the wagon to start working with</td><td>Long-Term Relevance: Perceived the database knowledge from the first task; Felt fun with the game from the beginning</td><td>Long-Term Relevance: H</td></tr>
<tr><td>Cognitive Tool</td><td>Cannot choose not to receive the explanations from Mushyman</td><td>Attention: Drew the attention of the participant by the immediate appearance of the tool and its explanations</td><td>Attention: VH</td><td rowspan="4">Cognitive curiosity: H/VH (cognitive tool)<br>Effort: H<br>Confidence: H(feedback)/ VH</td></tr>
<tr><td>Challenge</td><td>Feedback</td><td>Guided feedback</td><td rowspan="2">Attention: Attract the participant by telling him about his performance in doing the tasks in the game</td><td rowspan="2">Attention: H</td></tr>
<tr><td>Independence</td><td>Feedback</td><td>Can choose to/not to receive the feedback from Mary/James</td></tr>
<tr><td rowspan="2">Fantasy</td><td>Imagery</td><td>Visual graphics, audio graphics (background music & sound effects)</td><td>Attention: Caught the participant's attention instantly most of the time during interaction with the game</td><td>Attention: H</td></tr>
<tr><td>Content</td><td>Coherency of the storyline, embedded database knowledge in the tasks</td><td>Long-Term Relevance: Felt the coherency in the story and perceived the knowledge embedded in the storyline</td><td>Long-Term Relevance: H</td><td>Cognitive curiosity: H<br>Effort: H<br>Confidence: VH</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table C.4: Explanatory effects matrix of case study 2

The table can be explained in the following manner. The participant reported about his trait characteristics in a learning environment that he fancied challenging situations; however, he preferred to have a low control and did not like to be absolutely independent when learning (he preferred to get some help from a tutor). Based on his report, MoRes assigned him to play Alex's Adventure 3.0 in which he would be allowed to have a low control over the content and the cognitive tool. That is, he could not choose which storehouse/wagon he preferred to start working with when doing the tasks in the game (content); he also could not choose whether to receive the explanation from Mushyman after finishing doing each task (cognitive tool). In case the participant made a mistake during the tasks, he would not be offered a choice to receive the feedback, but he would be given the guided feedback straightaway.

As can be seen from the table, the instructional goals: support learning and provide fun were seen as having effects on the long-term relevance state of the participant directly since based on the data (see Figure C.2 for the plot of relevance which was measured against two instructional goals), this case was considered to have the goal in learning from the game and to have an intention to have fun with it from the start of the interaction. At the end of the game, the participant reported to have a high feeling that the game was relevant to his goals in the long-term as he reported that the game was enjoyable (the goal in having fun was fulfilled) and he could also learn some concepts in ERM within the new environment (the goal in learning was achieved).

Content which refers to the storyline and the knowledge embedded in the game is the feature that was also considered to have a direct effect on the state of long-term relevance. When looking at the plot of relevance which was measured against content (see Figure C.2), it was considered that the content of the game was likely to be able to fulfill both goals of the participant since the graph representing his feelings that the content was relevant to his goals falls into the same area (the high-value area) as the graphs representing his feelings that both instructional goals were relevant to his goals. After the interaction with the game was finished, the participant reported to have a high feeling that the content of the game was relevant to his goals in long-term as he reported that he enjoyed the storyline of the game and the knowledge was embedded properly in the story.

Cognitive tool, feedback and imagery are the features which were considered to have a direct effect on the attention state of the participant instead. According to the plot of attention measured against these three features (see Figure C.1), the participant reported to pay high attention to the imagery used in the game in general; however, there were some points in which the participant was not able to report his attention such as the scene where he reported not to spot anything interesting (snapshot 2) and the scene in which the setting was similar to that of the earlier scene (snapshot 6); an explanation about these incidents can be found in the description of Figure C.1 in section C.2.2. Similarly, the feedback given during the tasks in the game and the use of cognitive tool for explaining the knowledge embedded in the tasks were reported to be able to draw his attention. When the participant was asked about his overall attention at the end of the game, he reported to be strongly attracted to the cognitive tool and to pay high attention to the feedback and the imagery used in the game.

Apart from causing the direct effect as explained earlier, all these features were considered to cause the meta effects. Three motivational states were considered to be the meta effects: cognitive curiosity, effort and confidence. According to the data (see Figure C.3 for the plot of cognitive curiosity, effort and confidence), the values of cognitive curiosity were reported to be sustained at the level of high from the beginning to the middle part of the game (snapshot 1 – snapshot 4) before increasing to the level of very high in the scene where the cognitive tool was first presented (snapshot 5). However, the level of cognitive curiosity was reported to drop slightly to the level of high once again when the second task was given (snapshot 6) and remained at this level until the end of the game (snapshot 8); the drop might be because of the similarity in the later scenes compared to the earlier scenes that made it difficult to drive the cognitive curiosity of the participant once more. It was considered that for this motivational state it took a while before the value was driven to a very high level unlike the attention state of the participant which seems to be affected immediately as can be seen from its fluctuated values. Also, it was noticed that the value of cognitive curiosity, to some extent, related to the value of attention and of long-term relevance as can be seen from the plots of these motivational states, there are some similarities in some points among these plots. Hence, cognitive curiosity was considered to be the motivational state that was likely to be affected after attention and long-term relevance based on the evidence. As for the effort state, the participant reported to use a high effort from the start; however, the level of effort used was likely to change as he progressed through different scenes in the game. This incident was considered to happen because of the different degree of interaction provided in each scene. Again, we noticed some similarities in the plot points among the plot of effort, the plot of attention and the plot of long-term relevance; as a result, we considered effort as the motivational state that also seemed to be affected after attention and long-term relevance. The confidence state of the participant can be explained in a similar way. As can be seen from the plot of confidence (Figure C.3), the participant reported to have a very high level of confidence from the start to the end of the game; however, his confidence was reported to decrease slightly when he was told that he needed to do some tasks in the game in order to complete the mission (snapshot 3). Similar to cognitive curiosity and effort, there are some similarities in the plot points among the plot of attention, the plot of long-term relevance and the plot of effort; thus, confidence was also considered to be the motivational state that was likely to be affected after attention and long-term relevance. When the participant was asked to report the overall cognitive curiosity, effort and confidence at the end of the game, he reported to have a high level of cognitive curiosity, especially towards the feature – cognitive tool and he made a high effort and felt strongly confident when playing the game.

## C.3.2 Case Dynamics Matrix

Tables C.5, C.6, C.7 and C.8 are tables of case dynamics matrix which were created aiming to display how the features of the game cause changes in the values of motivational states.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">Underlying Issues<br>(as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H (#1 - #2)<br>VH (#3)</td><td rowspan="6">Cognitive curiosity:<br>H (#1 - #3)<br>Effort:<br>H (#1)<br>VH (#2 - #3)<br>Confidence:<br>VH (#1 - #2)<br>H (#3)</td><td rowspan="6">For long-term relevance:<br>- A high/very high value throughout the stage<br>For attention:<br>- A high/very high value throughout the stage<br>For cognitive curiosity:<br>- A high value throughout the stage<br>For effort:<br>- Increasing level of effort used throughout the stage (from the level of high to the level of very high)<br>For confidence:<br>- A high/very high value throughout the stage</td><td rowspan="6">For long-term relevance:<br>- Sustained the feelings of long-term relevance by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>For attention:<br>- Maintained/Increased the level of attention by using more colourful graphics in the following scenes<br>For cognitive curiosity:<br>- Preserved/Raised the level of curiosity by making use of the feature: content<br>For effort:<br>- Kept the level of effort by involving an activity which required more actions or thinking<br>For confidence:<br>- Sustained/Increased the level of confidence by making use of the feature: content</td></tr>
<tr><td>G: Provide fun</td><td></td><td>Long-Term Relevance:<br>VH (#1, #3)<br>H (#2)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H (#1 - #2)<br>VH (#3)</td></tr>
<tr><td></td><td>Cognitive Tool</td><td>Attention:<br>AS (#1 - #3)</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>VH (#1)<br>N/A (#2)<br>H (#3)</td></tr>
<tr><td></td><td>Feedback</td><td>Attention:<br>AS (#1 - #3)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table C.5: Case dynamics matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 2

As can be seen from Table C.5 (column: Underlying Issues (as seen by us)), the participant was highly attracted to the imagery used at the beginning and at the end of this stage; however, there was a point (snapshot 2) where he reported not to be able to spot anything interesting and thus, he could not report the level of his attention concerning the imagery used in that scene. Apart from being attracted to the imagery, the participant reported to feel interested to know what database knowledge he could learn from playing the game in this stage (a high feeling to learn); he also reported to feel interested in starting playing the game from the start of this stage. Furthermore, his cognitive curiosity and confidence was reported to be high as well as the effort he put on playing the game in this stage. Based on this piece of information, the strategies were specified in order to cope with the issues explained earlier (column: How to Cope with). It was considered that the game environment could consider maintaining/increasing the attention level of the participant and sustaining his high feeling to learn and to have fun. The explanation of why two choices of strategy were provided for dealing with the attention state while only one choice of strategy was provided for handling with the feeling to learn and the feeling of fun was the same as that made for case study 1 (see section 7.3.3.2). In order to maintain/increase the participant's attention, it was considered that more colourful graphics could be used in the subsequent scenes and to preserve his high feeling to learn and his high feeling of fun, the knowledge embedded in the game could be presented and more fun elements (e.g. surprised events or interactive activities) could be included in the following scenes. The presentation of knowledge was also expected to be capable of keeping the very high level of effort used from this stage to the next stage. In addition, the game could consider preserving/raising the level of cognitive curiosity and of confidence in the subsequent scenes as the value of these two motivational states were reported to be high at the end of the stage and it was considered that the feature – content could be exploited to achieve this.

Table C.6 (column: How Issues in Matrix 1 Resolved) shows how the strategies explained in the previous matrix could be implemented in the game environment and thus, our game prototype was unfolded[2] in order to serve this purpose. The first task was given to the participant along with the explanation about the knowledge embedded in the task. The revelation of the first task and the explanation aimed at sustaining the participant's feeling to learn and his high feeling of fun from the previous stage. Also, it aimed at preserving/raising his cognitive curiosity and keeping the very high level of effort used from the previous stage. Furthermore, during the task the participant was given a short praise for every correct choice and a guided feedback for every wrong choice; the feedback given concerning his performance aimed at strengthening his confidence. The colourful scenes and the funny look of cognitive tool were also used to maintain/increase his attention level. This implementation resulted in changes in the values of the participant's motivational states as shown in the column: Underlying Issues (as seen by us). The participant's feeling to learn from the game and his feeling of fun

[2] The term 'unfold' refers to the use of our game prototype as an example that implemented the anticipated changes in the game features according to the specified strategies.

were sustained at the end of this stage as well as his attention and cognitive curiosity. The participant reported to feel more confident from the last point of the previous stage; however, the effort used in this stage was reported to drop slightly from the previous stage, but it was still in a positive level. Based on this piece of evidence, the strategies were specified to deal with these issues (see column: How to Cope with). Another task was considered to be given to sustain his feeling to learn and his high feeling of fun; however, the task should not be excessively difficult in order to sustain his confidence, but it should be different from the first task to preserve his cognitive curiosity and to keep/raise the effort used in playing the game. In addition, the imagery used in the second task could be changed to attract the participant's attention.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">How Issues in Matrix 1 Resolved:</th><th rowspan="2">Underlying Issues (as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td><td rowspan="6">Cognitive curiosity:<br>H (#4)<br>VH (#5)<br>Effort:<br>H (#4 - #5)<br>Confidence:<br>VH (#4 - #5)</td><td rowspan="6">For long-term relevance:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For attention:<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>For cognitive curiosity:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For effort:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For confidence:<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4)</td><td rowspan="6">For long-term relevance:<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>For attention:<br>- A high attention towards the imagery at the beginning of the stage (#4)<br>- Not applicable to report about the attention towards feedback when it was first given (#4)<br>- A very high attention at the end of the stage (#5)<br>(Maintaining value from the previous stage)<br>For cognitive curiosity:<br>- A high/very high level of curiosity throughout the stage (Preserving value from the previous stage)<br>For effort:<br>- A high level of effort used throughout the stage<br>(Small drop in value, but still in the positive level compares to the previous stage)<br>For confidence:<br>- A very high confidence throughout the stage (Increasing value from the previous stage)</td><td rowspan="6">For long-term relevance:<br>- Sustained the feelings of long-term relevance by giving another task to do<br>For attention:<br>- Maintained the level of attention by making use of the feature: imagery<br>For cognitive curiosity:<br>- Preserved the level of curiosity by giving another task which should be slightly different from the first task<br>For effort:<br>- Kept/Raised the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>For confidence:<br>- Sustained the level of confidence by giving another task which should not be too hard compared to the first task</td></tr>
<tr><td>G: Provide Fun</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td></tr>
<tr><td>Cognitive Tool (#5)</td><td>Cognitive Tool (#4)</td><td>Attention:<br>AS (#4)<br>VH (#5)</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>H (#4)<br>VH (#5)</td></tr>
<tr><td>Feedback (#4)</td><td>Feedback (#5)</td><td>Attention:<br>N/A (#4)<br>AS (#5)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table C.6: Case dynamic matrix 2: 'The First Task' (snapshot 4 – snapshot 5) of case study 2

| ILE Features | | Motivational States | | How Issues in Matrix 2 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>VH (#6 - #7) | **Cognitive curiosity:**<br>H (#6 - #7)<br>**Effort:**<br>H (#6)<br>VH (#7)<br>**Confidence:**<br>VH (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>**For attention:**<br>- Not applicable to report about the attention towards imagery at the beginning of the stage (#6)<br>- A high/very high value paid to different features of the game throughout the stage (Small drop in value (but still in the positive level) at the beginning of the stage (#6); Increasing value at the end of the stage (#7))<br>**For cognitive curiosity:**<br>- A high value throughout the stage (Small drop in value, but still in the positive level compares to the previous stage)<br>**For effort:**<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>**For confidence:**<br>- A very high confidence throughout the stage (Maintaining value from the previous stage) | **For long-term relevance:**<br>- Sustained the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Maintained the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Preserved/Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Sustained the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>H (#6)<br>VH (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>VH (#6 - #7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>VH (#7) | | | | |
| Imagery | | **Attention:**<br>N/A (#6)<br>VH (#7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>H (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table C.7: Case dynamic matrix 3: 'The Second Task' (snapshot 6 – snapshot 7) of case study 2

Table C.7 (column: How Issues in Matrix 2 Resolved) shows how the strategies described earlier could be implemented in the game environment by taking our game prototype as an example. The participant was given the second task and the explanation about the task. The second task aimed at sustaining his feeling to learn and his high feeling of fun. Also, it was supposed to be able to preserve/increase the high level of cognitive curiosity and to keep the high level of effort used from the earlier stage. Similar to the first task, the participant was given the feedback regarding his performance in order to strengthen his confidence. Some changes were also made to the imagery used in the scene to maintain his attention. As a result of the implementation, the values of the participant's motivational states were affected as can be seen from the column: Underlying Issues (as seen by us). His feeling to learn and his feeling of fun were preserved to be at a high level throughout this stage as well as his confidence level; also, the high level of effort used in playing the game in the previous stage was sustained through this stage. However, there was a small drop in the value of attention at the beginning of the stage (snapshot 6), but the value was reported to increase at the end of the stage (snapshot 7). The values of cognitive curiosity was also reported to drop slightly in this stage. According to this, the strategies were specified to handle these issues (see column: How to Cope with). It was considered that the game could consider preserving/increasing the level of cognitive curiosity of the participant and sustaining his feeling to learn and his high feeling of fun as well as his confidence and the effort used in playing the game through the next stage; it was considered that this could be achieved by exploiting the feature – content (e.g. offering a new task or continuing the story). However, it was decided that the most suitable strategy in this research context is to continue the story rather than offering the new task (see section 7.3.3.2 for the same explanation as given for case study 1); as a result, the game was implemented in such that way. In addition, the feature – imagery was considered to be exploited in order to maintain the high attention of the participant.

| **ILE Features** | | **Motivational States** | | **How Issues in Matrix 3 Resolved:** | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:** H | **Cognitive curiosity:** H<br>**Effort:** H<br>**Confidence:** VH | **For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene - Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For long-term relevance:**<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>**For attention:**<br>- A high attention paid to the imagery used in this stage (Small drop in value, but still in the positive level compares to the previous stage)<br>**For cognitive curiosity:**<br>- A high level of curiosity in this last stage (Preserving curiosity from the previous stage)<br>**For effort:**<br>- A high level of effort used in this stage (Small drop in value, but still in the positive level compares to the previous stage)<br>**For confidence:**<br>- A very high confidence in this stage (Sustaining value from the previous stage) | - Resulted in satisfying outcome – the participant was finally motivated to learn with the game environment |
| G: Provide Fun | | **Long-Term Relevance:** VH | | | | |
| Content | | **Long-Term Relevance:** VH | | | | |
| | Cognitive Tool | **Attention:** AS | | | | |
| Imagery | | **Attention:** H | | | | |
| | Feedback | **Attention:** AS | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table C.8: Case dynamic matrix 4: 'The Finale' (snapshot 8) of case study 2

Table C.8 (column: How Issues in Matrix 3 Resolved) shows how the strategies described in the previous matrix could be implemented in the game environment (considering our game prototype as an example). The ending of the story was revealed – the main character could complete the mission successfully. The revelation of the ending aimed at sustaining the participant's feeling of fun as well as maintaining his confidence level. Also, it was supposed to be able to preserve/increase his cognitive curiosity to a high level in this stage. The colourful scene (as appeared in snapshot 8), presented earlier in the game, was shown once again to attract his attention (by making him guessed about the next event) and to encourage the use of high effort throughout this stage. As a result of this implementation, the values of all motivational states were reported to be high/very high in this last stage and when the participant was asked to report his overall motivation at the end of the game, he reported to be motivated to both learn and play with the game environment which was the satisfying outcome.

### C.3.3 The Revised Causal Model

The revised causal model of motivation of the case was produced and is shown in Figure C.4. The model aims at presenting all relevant variables (the ILE features and the motivational variables) and their relationships in a form of network. The motivational variables and the ILE features are represented by nodes whereas the relationships among them are represented using links. The details about the links can be explained in the same way as in case study 1 (see section 7.3.3.3 for the explanation).

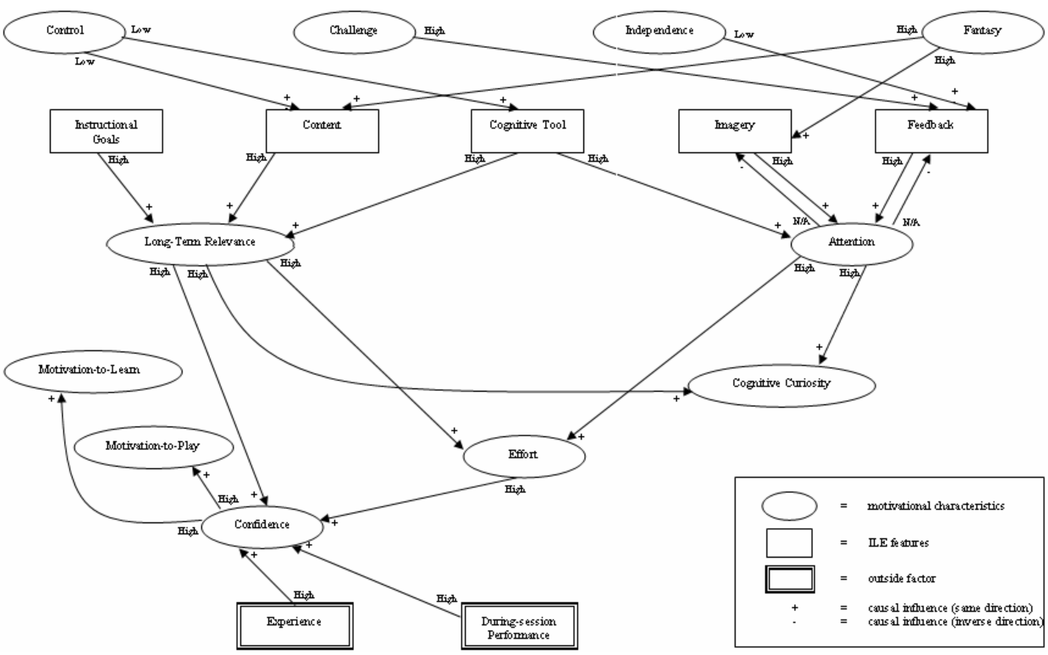


Figure C.4: The revised causal model of motivation of case study 2

The story of the model can be told as two related parts. The first part of the story describes the relationships between the trait characteristics of the participant (independent variables) and the features of the game ILE (dependent variables that vary according to the trait characteristics). The story of this part starts when the participant reported about his trait characteristics in a learning environment that he fancied challenging situation. However, he rather chose not to have control over the learning materials and he did not want to be independent when learning (he preferred to get some helps from a tutor when facing with difficult situations); hence, MoRes assigned him to play Alex's Adventure 3.0 where he would not be allowed to have control over the content of the game including the cognitive tool (the tool can be regarded as a part of the content as explained in case study 1). Furthermore, if the participant made a mistake during the tasks, he would be given the guided feedback which is more challenging than the direct feedback. This design attempts to make the game better matched with the low-control, high-challenge and low-independent characteristics of the participant.

The second part of the story explains the relationships between the features of the game and the state characteristics of the participant. These two types of variables can be viewed as both the independent and the dependent variables (see the explanation in case study 1). The story of this part begins when the participant started the interaction with the game environment. Based on the data (see Figure C.1 for the plot of attention, Figure C.2 for the plot of relevance and Figure C.3 for the plot of cognitive curiosity, effort and confidence), it was considered that the features of the game environment could exert some influences on the motivational states of the participant as there are fluctuations in the graphs appeared in those plots which means the values of the participant's motivational states can vary according to the scenes presented. Indeed, there are some similarities and some differences among these scenes; thus, some of them may contain the same features and some of them may consist of different features. That is to say the features included in a single scene could play an important role in the change in the values of the motivational states.

Generally, the use of imagery in the game ILE and the feedback given during the tasks in the game could attract the participant's attention straight away throughout the interaction and thus, two links were drawn from the features: imagery and feedback, to attention to represent the relationships between these features and the attention state of the participant. However, there were some points where the participant was not able to report his attention towards these two features (snapshots 2, 4 and 6 in Figure C.1) and hence, another two links were drawn backward from attention to these features in order to show that the imagery and the feedback could be adjusted in order to raise the attention level of the participant. The use of cognitive tool could catch the participant's attention strongly whenever it was presented in the game and as a result, there was a link drawn from the feature – cognitive tool, to attention to demonstrate the relationship between this feature and the attention state.

Also, as can be seen from the plot of relevance (Figure C.2), the participant reported to have a high feeling to learn from the game and a high feeling of fun throughout the game. This shows the correspondence between the instructional goals (support learning and provide fun) and the goals of the participant in learning and in having fun with the game; the correspondence can be regarded as long-term relevance since the goals occurred from the start and were fulfilled throughout the game interaction. It was also considered that content could play an important role in maintaining the feelings of long-relevance of the participant (as can be seen from the plot of relevance – all graphs fall into the same area). Based on this piece of evidence, two links were drawn from the features: instructional goals and content, to long-term relevance to represent the relationships between these two features and the relevance state of the participant. As shown in Figure C.2, the feelings that the game was relevant to his goal in learning were reported to be very high in snapshots 5 and 7 where the tool was presented. As a result, another arrow was drawn from the feature – cognitive tool, to long-term relevance to show the effect of the tool on this motivational state.

On the contrary, the other three motivational states: cognitive curiosity, effort and confidence were considered to be affected by either attention or relevance, or both, according to the literature described in section 4.2.3. Based on the literature and looking from the plot of cognitive curiosity, effort and confidence (Figure C.3), the plot of attention (Figure C.1) and the plot of relevance (Figure C.2), it seems that the value of cognitive curiosity at each point in the plot was considered to be driven by attention and long-term relevance in a straightforward way. That is, when the value of attention and of relevance fall into the high-value area (Attention/Relevance Value = 4 and Attention/Relevance Value = 5), the value of cognitive curiosity also falls into the same area. Based on this, two links were drawn from the motivational states: attention and long-term relevance, to cognitive curiosity to represent the relationships among them.

Similarly, the effort used in playing the game was also likely to be influenced by attention and long-term relevance. From the comparison of the plots of these motivational states, there are similarities among the value of effort, of attention and of relevance; the plots fall into the same positive-value area (the high-value area) even though at some specific points in the game the values of these states were not exactly the same (snapshots 2 and 5). To represent the relationships among these three motivational states, two links were drawn from attention and long-term relevance to effort.

A slightly different explanation is made for confidence. According to the the plot of cognitive curiosity, effort and confidence (Figure C.3), the plot of attention (Figure C.1) and the plot of relevance (Figure C.2), it seems that the values of confidence was influenced by two motivational states: long-term relevance and effort; generally, the values of these motivational states fall into the same area (the high-value area) even though the value of each of these states is not exactly the same for every single point in the game. It was considered that the values of confidence at these points might be influenced by the ‘outside factors’: during-session performance and experience similar to case study 1. As reported by the participant, he plays several kinds of computer games and video games on regular basis which shows his high experience in computer games; this might be reflected as a reason why he reported to have a very high confidence through the session with the game. Performance was also the factor that might play an important role in the participant’s confidence. As can be seen from Figure C.3, his confidence was reported to drop from a very high level to a high level in snapshot 3 where the tasks in the game were mentioned (the mention of the tasks might make the participant felt slightly unsure whether he could do it well); however, in the following snapshot in which the first task was presented, it appeared that he could perform the task very well and got the highest score which resulted in an increase in his confidence level once again. As a result, four links were drawn from long-term relevance, effort, experience and during-session performance to confidence in order to represent their relationship.

## C.4 Summary of Case Study 2

This case can also be regarded as a normal ‘motivated’ case since the participant reported to be motivated to learn after the interaction with the game prototype was finished.

The participant was asked to provide the trait characteristics in a learning environment and based on his report, he was assigned to play Alex’s Adventure 3.0 which was considered to be the version of the game that suit with his traits. The trait characteristics of the case are shown in Table C.1. After the session with the game was finished, he was asked to report about his motivational states during interaction and his overall motivational states at the end of the game. The data concerning the motivational states of the case during interaction was presented using the event listing table (Table

C.2) and three plots of motivational states (Figure C.1 – Figure C.3). The effects matrix of ILE features (Table C.3) was used for describing the effects of the game features on the motivational states of the case. The causal mechanisms between the trait characteristics, the features of the game and the state characteristics were revealed using the explanatory effects matrix (Table C.4) and four case dynamics matrices (Table C.5 – Table C.8). The revised causal model of motivation of the case was also created in order to present these causal mechanisms in a coherent picture (Figure C.4).

Some key findings can be drawn from the study of this case:

- To raise the level of attention, the features: imagery and feedback, could be adjusted (e.g. changing the setting used in later scenes, changing the style of feedback given to the participant concerning his performance)
- Similar to case study 1 and case study 6, confidence was the motivational state that might be influenced by the outside factors: during-session performance and experience; however, it was not obvious whether these factors could also have an influence on the other motivational states.

# Appendix D

# The Analysis of Case Study 3

This appendix presents the analysis of case study 3 (case E12). The analysis was done in a similar fashion compared to the other three cases (case study 1 and case study 6 (chapter 7), case study 2 (Appendix C)).

# D.1 Background of Case Study 3

The participant is a female gender whose age is age is between 20 – 25 years old. She is a British student and is doing her master degree in computing science. She has no significant knowledge in database modelling, but had some experience in creating databases using database software – Microsoft Access and Oracle. She enjoys playing computer games and has played several kinds of game e.g. role-playing game, puzzle game, etc. At the start of the session with MoRes, the participant was asked to provide the data about some of her trait characteristics in a learning environment. The trait characteristics of the participant are shown in Table D.1.

Based on her trait characteristics, MoRes assigned her to play Alex's Adventure 4.0[1].

| Control | Challenge | Independence | Fantasy |
|---|---|---|---|
| High | Low | Low | High |

Table D.1: Trait characteristics of case study 3

# D.2 Representations for Describing the Motivation of Case Study 3

## D.2.1 Event Listing of Motivational State

Table D.2 is a table of event listing which was created based on the data reported through the use of a retrospective self-report.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Attention | Imagery | VH | H | H | H | VH | H | VH | VL |
| | Feedback | AS | AS | AS | L | AS | L | AS | AS |
| | Cognitive Tool | AS | AS | AS | AS | H | AS | VH | AS |
| Relevance | Content | H | H | H | H | VH | VH | VH | VH |
| | Goal: Support Learning | H | VH | H | H | VH | VH | VH | VH |
| | Goal: Provide Fun | VH | L | H | L | VH | L | VH | VH |
| Cognitive Curiosity | | VH | H | VH | L | H | L | H | VH |
| Effort | | H | H | VH | H | VH | H | VH | H |
| Confidence | | VH | VH | H | H | VH | VH | VH | VH |

Legend:
VL = Very Low
L = Low
N/A = Not Applicable
H = High
VH = Very High
AS = Absent feature from the scene

Table D.2: Event listing of motivational state of case study 3

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[1] The specifications of Alex's Adventure 3.0 were described in chapter 5 (section 5.3.1.4).

Based on the data shown in the table and our observational notes, the participant seemed to feel attentive to the beginning scenes (stared at the scenes all the time; moved the top body closer to the screen when reading the introduction to all characters in the 'Invitation' scene). Also, she seemed to be curious to start playing the game (clicked the button 'Play Game' immediately). In the following scene ('In the Forest' scene) where the character – Blockhead was introduced, the participant seemed to be interested in the conversation between this character and the main character – Alex. When she was asked to find all hidden mushrooms in the forest in order to proceed to the subsequent scenes, she seemed to be curious and made an effort in finishing this activity (looked over the screen for the mushrooms **(:G1)**). After the participant completed the activity and saw the scene was changing, she looked satisfied **(:F1)**. In the 'Meet Dr de Ville' scene the participant was likely to be attracted by the appearance of the other two characters (Dr de Ville and Mary) were introduced and she looked interested in the conversation that happened among these characters (seemed to think along **(:G2)** and clicked the button to close the conversation dialogs quicker as time passing **(:G3)**); however, she seemed to be doubtful at first when she was not able to move the main character, but appeared to be relieved when seeing the other character (Dr de Ville) walking towards the main character instead. In the following scene ('First Task' scene) the participant was likely to be attracted by objects and dialog boxes describing the scenario of the task and how to complete it (looked over the screen **(:G4)**); also, she seemed to be highly concentrated when doing the task (checked the information kept in each chest before choosing which one to move **(:G5)** and some chests was checked several times **(:G6)**); the participant could finish the first task with the highest score and looked satisfied **(:F1)**. In the 'Meet Mushyman #1' scene where the character – Mushyman, first appeared to explain the knowledge embedded in the task, the participant's attention was likely to be drawn by its appearance and its explanation (looked alert **(:F2)**). Also, she seemed to make an effort in understanding the knowledge behind the task (moved the mouse along the explanation when reading **(:G7)**, **(:G2)**). In the two subsequent scenes ('Second Task' scene and 'Meet Mushyman #2' scene) in which the participant was asked to do the second task and was presented with the explanation about the task, her feelings were reported to be similar to those in the earlier scenes. In the last scene the participant seemed to be attracted by the presentation of the scene and looked curious about what was going to happen in this scene (moved the main character to Emma's house without bothering to wander around the scene **(:G8)**). When the session with the game was finished, the participant looked relieved (**(:F1)**).

## D.2.2 Plot of Motivational State

Three plots of motivational states were developed: the plot of attention which was measured against three features: imagery, feedback and cognitive tool, the plot of relevance which was measured against two features: instructional goal (support learning and provide fun) and content, and the plot of cognitive curiosity, effort and confidence.

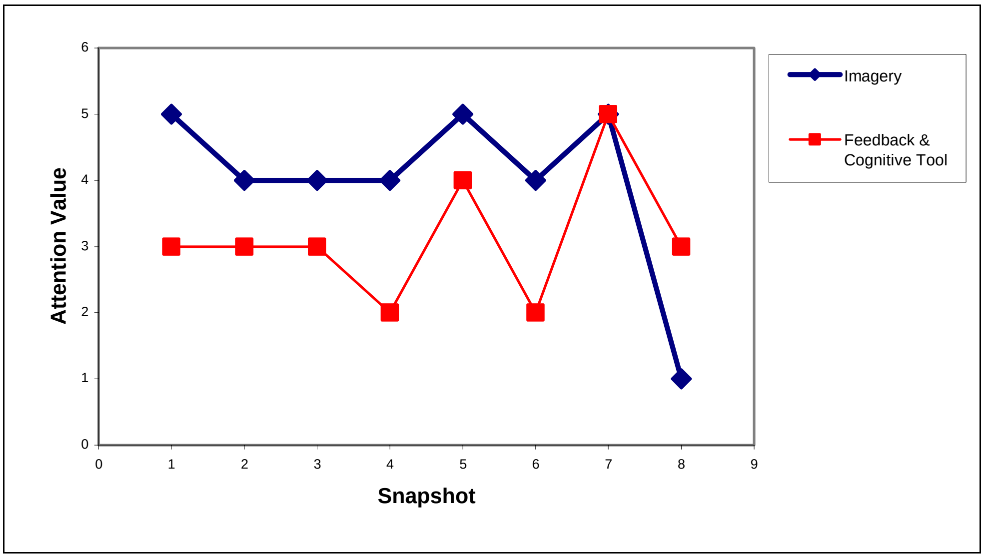


Figure D.1: Attention value towards three features of the game during interaction

Figure D.1 shows the values of the participant's attention towards three features of the game: imagery, feedback and cognitive tool during interaction. From the figure, it can be said that the participant paid high attention to the imagery used in the game in general as the graph generally falls into the high-value area (Attention Value = 4 and Attention Value = 5). However, the participant reported to pay very low attention (Attention Value = 1) nearly at the end of the game where the repetitive scene was used (snapshot 8). In addition, as can be seen from the figure, the participant also paid high attention to the cognitive tool used for explaining the knowledge embedded in the game (Attention Value = 4 and Attention Value = 5). However, the participant did not pay much attention to the feedback given during the tasks in the game (Attention Value = 2); according to her report, this feature could not draw her attention powerfully since the feedback given in both tasks are the same (the participant performed the tasks very well and thus, she always received a short praise such as 'Well done' and 'Excellent as a reward).

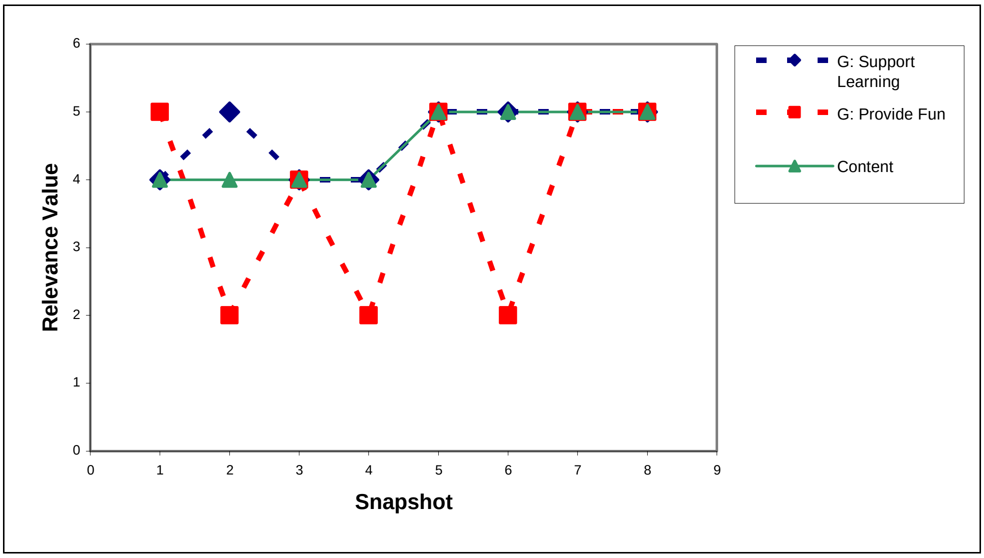


Figure D.2: Relevance value towards two features of the game during interaction

Figure D.2 shows the feelings of relevance between the participant's goals and two features of the game: instructional goals (support learning and provide fun) and content. According to the figure, the participant seemed to have the goal to learn from the start of the game since her feelings that the game was relevant to her goal in learning were reported to vary between the level of high and of very high throughout the interaction with the game. However, her feeling of fun was reported to vary between the level of low (Relevance Value = 2) and of very high (Relevance Value = 5). It is noticeable that the participant was likely to feel less fun in snapshots 2, 4 and 6 where she was asked to complete an activity/some tasks in order to proceed to the next scene; the drop in her feeling of fun might be because she could perform the activity/tasks very well and thus, she might consider the activity/tasks were fairly easy for her. Also, as can be seen from the figure, the participant felt that the content of the game is relevant to her goal in the long-term as the values of her feelings of relevance were reported to be high or very high throughout the game (Relevance Value = 4 and Relevance Value = 5); the value was reported to be high from the start of the game to the middle of the game (snapshot 1 – snapshot 4) before increasing to a very high level in snapshot 5 and remains at this level until the end of the game.

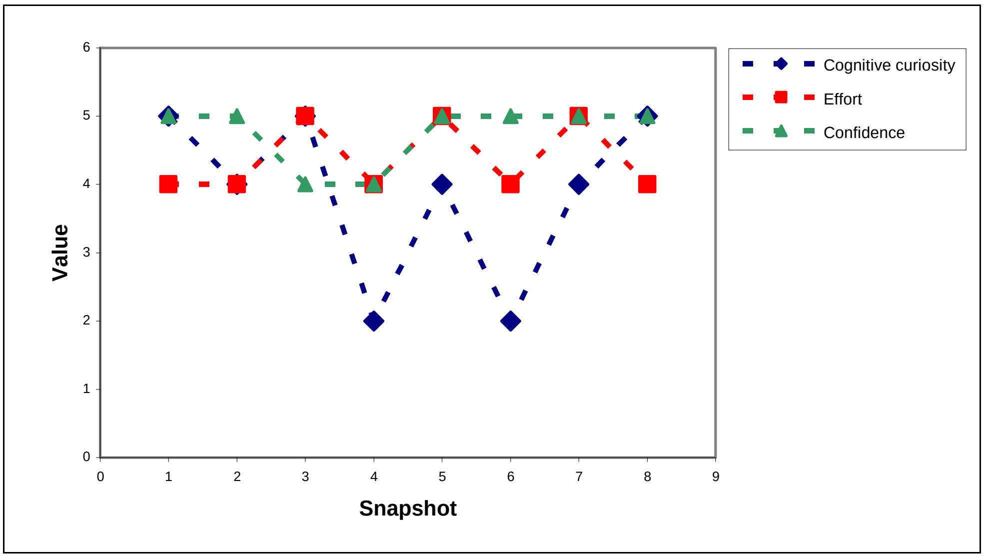


Figure D.3: The value of cognitive curiosity, of effort and of confidence during interaction

Figure D.3 shows the values of the following motivational states of the participant during interaction: cognitive curiosity, effort and confidence. As can be seen from the figure, the values of cognitive curiosity were reported to vary between the value of low (Cognitive Curiosity Value = 2) and of very high (Cognitive Curiosity Value = 4 and Cognitive Curiosity Value = 5). The participant reported to have a low cognitive curiosity when she was given the academic-related tasks to complete (snapshots 4 and 6); according to her report, she felt less curious when doing the tasks because both tasks were similar and the feedback given during the tasks were the same. On the contrary, her confidence level and the effort used in playing the game were reported to be high or very high throughout the interaction.

## D.2.3 Effects Matrix of ILE Features

Table D.3 is a table of effects matrix and it was created aiming to describe the effects of game features on the participant's motivational states. The description of the table (below) was created based on existing literature as explained in chapter 4 (section 4.2.3) and evidences (data from post-questionnaire, self-report, observational notes and semi-structured interview).

| ILE Features | Direct Effects + | Direct Effects - | Meta Effects + | Meta Effects - | Side Effects + |
|---|---|---|---|---|---|
| Imagery | Attracted the attention of the participant instantly | Less attention paid to the scene that was used repeatedly | Curious to see the following scenes | | |
| Feedback | | Less attention paid to the feedback given in both tasks as they were the same | | Less curious about what feedback would be given | |
| Cognitive Tool | Felt highly attentive to the immediate appearance of the tool and its explanations about the tasks | | Curious about how the tasks were relevant to databases | | |
| Content | A high interest in the story of the game and the relevance between the game and the embedded knowledge | | Wonder how the story would end and how the game was relevant to databases | | Widen the participant's view about learning databases in a new environment other than a classroom setting |
| Instructional goals | Wanted to learn and to have fun from playing the game and the game could fulfil these feelings | | | | |

Sources: Post-questionnaire, retrospective self-report, observational notes and semi-structured interview

Table D.3: Effects matrix of ILE features of case study 3

According to the table, it seems that in general, the use of imagery in the game could attract the participant's attention instantly throughout the game and it also made her felt curious about the following scenes. However, the participant reported to pay low attention to the scene which was used repeatedly such as the last scene – the 'Back to Emma' scene; furthermore, according to our observational notes, the participant looked somewhere else for a little while nearly at the end of the game. When the first and the second task were given to the participant, she reported to pay low attention to the feedback given during both tasks as she always received similar praise ('Not bad', 'Excellent', 'Well done') whenever she made the right choice; this also made her felt less curious about what feedback she would get after each choice. However, she seemed to be highly attracted to the appearance of the cognitive tool after each task was finished and curious to see its explanation regarding the knowledge embedded in the tasks. As for the content of the game, the participant reported to have a high interest in the story of the game and wonder how it would end; she also felt curious about the relevance between the game and the concepts of ERM in databases. At the end of the game, the participant reported to have a wider view about learning databases in a new environment other than a classroom setting.

# D.3 Representations for Explaining the Motivation of Case Study 3

## D.3.1 Explanatory Effects Matrix

Table D.4 is a table of explanatory effects matrix which was developed in order to display the overall picture of the relationships among trait characteristics, ILE features and state characteristic. Similar to the case studies presented in chapter 7, the explanation of the table was created based on existing literature (see section 4.2.3) and evidences (data from post-questionnaire and self-report) which were considered to support the literature to some degree.

<table>
<tr><th rowspan="2">Trait</th><th rowspan="2">ILE Features</th><th rowspan="2">Game Characteristics</th><th colspan="2">Short-Run Effects<br>(process perspective on state)</th><th colspan="2">Longer-Run Consequences<br>(overall-state perspective)</th></tr>
<tr><th>Direct Effects</th><th>Meta Effects</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td rowspan="2"></td><td>Instructional goal: Support Learning</td><td></td><td>Long-Term Relevance: the goal was likely to exist from the start and was achieved throughout the session</td><td rowspan="8">Cognitive curiosity: A high level of curiosity in general except when the feedback was given during the tasks<br>Effort: Sustaining high level of effort used in playing the game; A very high level of effort used in the scenes that required more action/thinking from the participant<br>Confidence: Generally, a very high level of confidence was sustained throughout the game except when the tasks in the game was mentioned and the first task was given</td><td>Long-Term Relevance: VH</td><td rowspan="3">Cognitive curiosity: H<br>Effort: VH<br>Confidence: VH</td></tr>
<tr><td>Instructional goal: Provide Fun</td><td></td><td>Long-Term Relevance: Another goal of the participant that seemed to exist from the beginning and was accomplished throughout the session</td><td>Long-Term Relevance: VH</td></tr>
<tr><td rowspan="2">Control</td><td>Content</td><td>Can choose the storehouse/the wagon to start working with</td><td>Long-Term Relevance: Perceived the database knowledge from the first task; Generally, felt fun throughout the game, but felt less fun in the scenes in which the tasks were given</td><td>Long-Term Relevance: VH</td></tr>
<tr><td>Cognitive Tool</td><td>Can choose not to receive the explanations from Mushyman</td><td>Attention: Caught the attention of the participant by the immediate appearance of the tool and its explanations</td><td>Attention: VH</td><td rowspan="4">Cognitive curiosity: H/VH (cognitive tool)<br>Effort: H/VH (cognitive tool)<br>Confidence: H/VH (cognitive tool)</td></tr>
<tr><td>Challenge</td><td>Feedback</td><td>Direct feedback</td><td rowspan="2">Attention: Paid less attention to the feedback given during the tasks in the game due to the use of the same feedback style</td><td rowspan="2">Attention: H</td></tr>
<tr><td>Independence</td><td>Feedback</td><td>Can choose to/not to receive the feedback from Mary/James</td></tr>
<tr><td rowspan="2">Fantasy</td><td>Imagery</td><td>Visual graphics, audio graphics (background music & sound effects)</td><td>Attention: Attracted the participant's attention instantly most of the time except when the scene was used repeatedly</td><td>Attention: H</td></tr>
<tr><td>Content</td><td>Coherency of the storyline, embedded database knowledge in the tasks</td><td>Long-Term Relevance: Felt the coherency in the story and perceived the knowledge embedded in the story</td><td>Long-Term Relevance: VH</td><td>Cognitive curiosity: H<br>Effort: VH<br>Confidence: VH</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table D.4: Explanatory effects matrix of case study 3

The table can be explained in the following way. The participant reported about her trait characteristics in a learning environment that she preferred to have a high control; however, she did not like challenging situations and did not want to be very independent when learning (she preferred to get some help from a tutor). According to her report, she was assigned by MoRes to play Alex's Adventure 4.0 in which she could have control over the features: content and cognitive tool. That is, she could choose the storehouse/wagon she preferred to start working with when doing the tasks in the game (content); also, she could choose whether to receive the explanation from Mushyman after finishing with each task (cognitive tool). Furthermore, if she made a mistake during the tasks, she would receive the direct feedback informing explicitly about what was wrong and what was supposed to be right.

As shown in the table, two instructional goals (support learning and provide fun) were seen as having effects on the long-term relevance state of the participant directly. Based on the data (see Figure D.2 for the plot of relevance), it was considered that this case seemed to have the goal in learning and intend to have fun with the game from the start of the interaction. The participant also reported at the end of the interaction that she had the feelings that the game instruction was highly relevant to her goals since she reported to enjoy the story of the game (the goal in having fun was fulfilled) and she could learn some concepts of ERM from playing the game (the goal in learning was fulfilled).

Content (the story and the knowledge embedded in the game) is the feature that was also considered to have a direct effect on the long-term relevance state. When looking at the plot of relevance which was measured against the feature – content (see Figure D.2), it was considered that the content of the game could fulfill both goals of the participant as the graph showing her feelings that the content was relevant to her goals falls into the same area as the graphs showing her feelings that both instructional goals were relevant to her goals. However, there were some points in the game in which the participant's feeling of fun was reported to drop to a low level (snapshots 2, 4 and 6). But, this did not seem to cause a major effect since at the end of the game, the participant reported that she felt highly satisfied with the content of the game since the storyline was enjoyable and she could learn some concepts of ERM from playing the game.

On the contrary, cognitive tool, feedback and imagery are the features which were considered to affect the participant's attention directly. According to the plot of attention which was measured against these features (see Figure D.1), the participant reported to pay high attention to the imagery used in the game throughout the interaction except in the last scene (snapshot 8) where the participant reported to pay low attention because the scene was repetitive. Similarly, the use of cognitive tool could draw her attention. However, the participant reported to feel less attracted to the feedback given during the tasks (snapshots 4 and 6) because of the same feedback style used in both tasks. When the participant was asked to report her overall attention, she reported to pay very high attention to the cognitive tool whereas a high level of attention was reported to be paid to the feedback and the imagery.

Apart from causing the direct effect as previously explained, all these features were considered to also cause the meta effects. Three motivational states were considered to be the meta effects: cognitive curiosity, effort and confidence. According to the data (see Figure D.3 for the plot of cognitive curiosity, effort and confidence), the values of cognitive curiosity was considered to be influenced by attention and long-term relevance as there are some similarities in some points among the plots of these motivational states. Based on this piece of evidence and the literature in section 4.2.3 that described the plausible order of the motivational states appeared in the preliminary model (see section 4.2.3), cognitive curiosity was considered to be the motivational state that was likely to be affected after attention and long-term relevance.

As for the effort state, the participant reported to put a high effort on playing the game from the start. However, the level of effort used was reported to vary according to the scenes presented in the game; a very high effort was reported to be used in the scenes that require thinking rather than actions from the participant (snapshots 3, 5 and 7). Similar to cognitive curiosity, we noticed some similarities in the plot points among the plot of effort, the plot of attention and the plot of long-term relevance. Thus, we considered effort as the motivational state that was likely to be affected by attention and long-term relevance based on this piece of information and also, the literature in section 4.2.3.

Confidence is the motivational state that can be explained in a similar way. As can be seen from the plot of confidence (see Figure D.3), the participant reported to have a very high level of confidence throughout the interaction with the game. However, there were two points where her confidence was reported to drop slightly to a high level; the first point was when she was told that she needed to do some tasks in the game in order to complete the mission (snapshot 3) and the second point was when the first task was given (snapshot 4). Similar to cognitive curiosity and effort, there are some similarities in the plot points among the plot of attention, the plot of long-term relevance and the plot of effort. According to this and the literature in section 4.2.3, confidence was also considered to be the motivational state that was likely to be affected after attention and long-term relevance.

## D.3.2 Case Dynamics Matrix

Tables D.5, D.6, D.7 and D.8 were created aiming to display how the features of the game cause changes in the values of the motivational states.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">Underlying Issues<br>(as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H (#1, #3)<br>VH (#2)</td><td rowspan="6">Cognitive curiosity:<br>VH (#1, #3)<br>H (#2)<br>Effort:<br>H (#1 - #2)<br>VH (#3)<br>Confidence:<br>VH (#1 - #2)<br>H (#3)</td><td rowspan="6">For long-term relevance:<br>- A high/very high value throughout the stage<br>For attention:<br>- A very high value at the start of the stage (#1)<br>-A low value when the participant was asked to complete a task (#2)<br>- A high value at the end of the stage (#3)<br>For cognitive curiosity:<br>- A high/very high value throughout the stage<br>For effort:<br>- Increasing level of effort used throughout the stage (from the level of high to the level of very high)<br>For confidence:<br>- A very high value at the beginning of the stage (#1 - #2)<br>- A high value at the end of the stage (#3)</td><td rowspan="6">For long-term relevance:<br>- Sustained/Increased the feelings of long-term relevance by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>For attention:<br>- Maintained/Raised the level of attention by using more colourful graphics in the following scenes<br>For cognitive curiosity:<br>- Preserved the level of curiosity by making use of the feature: content<br>For effort:<br>- Kept the level of effort by involving an activity which required more actions or thinking<br>For confidence:<br>- Sustained/Increased the level of confidence by making use of the feature: content</td></tr>
<tr><td>G: Provide fun</td><td></td><td>Long-Term Relevance:<br>VH (#1)<br>L (#2)<br>H (#3)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H (#1 - #3)</td></tr>
<tr><td></td><td>Cognitive Tool</td><td>Attention:<br>AS (#1 - #3)</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>VH (#1)<br>H (#2 - #3)</td></tr>
<tr><td></td><td>Feedback</td><td>Attention:<br>AS (#1 - #3)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table D.5: Case dynamic matrix 1: 'The Prelude' (snapshot 1 – snapshot 3) of case study 3

As can be seen from Table D.5 (column: Underlying Issues (as seen by us)), the participant was highly attracted to the imagery used in this stage and she also reported to feel interested to learn from playing the game from the start of the stage. Her feeling of fun was also reported to be very high at the beginning of the stage, but the feeling dropped to a low level in the middle of the stage when the participant was asked to complete an activity before progressing through the next scene (snapshot 2); however, this did not seem to have a strong effect since the feeling was finally lifted up to a high level once again at the end of the stage. The level of her cognitive curiosity, effort and confidence was also reported to be high/very high throughout the stage. According to these issues, the strategies were specified as shown in the column: How to Cope with. It was considered that the game environment could consider maintaining/raising her attention level, her feeling to learn and her feeling of fun to be at a high/very high level. The explanation of why two choices of strategy were provided for dealing with those motivational states was the same as that made for case study 1 (see section 7.3.3.2). To maintain/raise the attention level, more colourful graphics was considered to be used in the following scenes. To sustain/increase her high feeling to learn and her high feeling of fun, the knowledge embedded in the game was considered to be presented and more fun elements (such as surprised events or interactive activities) were included in the consecutive scenes. The presentation of the knowledge was also expected to be able to preserve the very high level of cognitive curiosity and of effort from this stage to the next stage. In addition, the game could consider sustaining/increasing the level of confidence of the participant in the subsequent scenes by utilising the feature – content since the value of this motivational state was reported to be high at the end of this stage.

| ILE Features | | Motivational States | | How Issues in Matrix 1 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#4)<br>VH (#5) | **Cognitive curiosity:**<br>L (#4)<br>H (#5)<br>**Effort:**<br>H (#4)<br>VH (#5)<br>**Confidence:**<br>H (#4)<br>VH (#5) | **For long-term relevance:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For attention:**<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>**For cognitive curiosity:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For effort:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4) | **For long-term relevance:**<br>- Varying value (from the value of low to the value of very high) throughout the stage<br>(A drop in the feeling of fun at the beginning of the stage, but increasing feeling at the end of the stage; Sustaining feeling of learning from the previous stage)<br>**For attention:**<br>- A high/very high attention towards the imagery throughout the stage<br>- A low attention towards feedback when it was first given (#4)<br>- A high attention towards the cognitive tool (#5)<br>(Maintaining value at the end of the stage)<br>**For cognitive curiosity:**<br>- Varying level of curiosity throughout the stage (from the level of low to the level of high)<br>(Preserving value at the end of the stage)<br>**For effort:**<br>- A high/very high level of effort used throughout the stage<br>(Sustaining value from the previous stage)<br>**For confidence:**<br>- A high/very high confidence throughout the stage<br>(Maintaining value from the previous stage) | **For long-term relevance:**<br>- Sustained the feelings of long-term relevance by giving another task to do<br>**For attention:**<br>- Maintained the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Preserved/Increased the level of curiosity by giving another task which should be slightly different from the first task<br>**For effort:**<br>- Kept the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>**For confidence:**<br>- Sustained the level of confidence by giving another task which should not be too hard compared to the first task |
| G: Provide Fun | | **Long-Term Relevance:**<br>L (#4)<br>VH (#5) | | | | |
| Content | | **Long-Term Relevance:**<br>H (#4)<br>VH (#5) | | | | |
| Cognitive Tool (#5) | Cognitive Tool (#4) | **Attention:**<br>AS (#4)<br>H (#5) | | | | |
| Imagery | | **Attention:**<br>H (#4)<br>VH (#5) | | | | |
| Feedback (#4) | Feedback (#5) | **Attention:**<br>L (#4)<br>AS (#5) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table D.6: Case dynamic matrix 2: ‘The First Task’ (snapshot 4 – snapshot 5) of case study 3

Table D.6 (column: How Issues in Matrix 1 Resolved) illustrates how the strategies explained in the previous matrix could be implemented in the game environment and thus, our game prototype was unfolded[2] in order to serve this purpose. The first task was presented to the participant and after the task was finished, the explanation about the knowledge embedded in the task was given. The revelation of the first task and the

[2] The term ‘unfold’ refers to the use of our game prototype as an example that implemented the anticipated changes in the game features according to the specified strategies.

explanation aimed at sustaining/increasing the high feeling to learn and the high feeling of fun of the participant. Also, it aimed at preserving the very high level of cognitive curiosity and of effort from the previous stage. Moreover, during the task, the participant was given a short praise for every correct choice and a guided feedback for every wrong choice; the feedback concerning her performance aimed at strengthening her confidence. The colourful scenes and the funny look of cognitive tool were used to maintain/raise the attention level of the participant. As a result of this implementation, the values of the participant's motivational states were changed as can be seen from the column: Underlying Issues (as seen by us). The high feeling to learn and the high feeling of fun of the participant were sustained at the end of the stage as well as the value of other motivational states. However, the confidence of the participant was reported to increase to the level of very high at the end of the stage. Based on these issues, the strategies were specified as appeared in the column: How to Cope with. Another task was considered to be given to sustain the participant's feeling to learn and her feeling of fun with the game; the task should not be very difficult, but should be different from the previous task in order to maintain the high level of confidence and of effort through the next stage and to preserve/increase her high level of cognitive curiosity. In addition, the imagery used in the second task could be changed to maintain her high level of attention.

Table D.7 (column: How Issues in Matrix 2 Resolved) shows how the strategies explained earlier could be implemented in the game environment by taking our game prototype as an example. The participant was given the second task and the explanation about the knowledge embedded in the task. The second task aimed at sustaining the feeling to learn and the feeling of fun with the game. Also, it was supposed to be able to preserve/increase her cognitive curiosity and the effort used from the previous stage to be at a high/very high level. Similar to the first task, the participant was given the feedback concerning her performance in order to strengthen her confidence. The theme of the scene used in this stage was also changed to maintain her attention. This implementation caused some changes in the values of the participant's motivational states as can be seen from the column: Underlying Issues (as seen by us). The feeling to learn and the feeling of fun were likely to be sustained at the end of the stage as well as the values of other motivational states. Similarly, the strategies were specified to deal with the issues explained so far as shown in the column: How to Cope with. The game could consider preserving/increasing the high level of the participant's cognitive curiosity and sustaining the strong feeling to learn and her feeling of fun as well as the high level of confidence and of effort used in this stage; this was considered to be able to achieve by exploiting the feature – content, either offering a new task or continuing the story. However, it was decided that the most suitable strategy in this research context is to continue the story rather than presenting the new task (see section 7.3.3.2 for the same explanation as given for case study 1)); hence, the game was implemented in such that way. In addition, the feature – imagery, was exploited to sustain the attention of the participant.

| ILE Features | | Motivational States | | How Issues in Matrix 2 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>VH (#6 - #7) | **Cognitive curiosity:**<br>L (#6)<br>H (#7)<br>**Effort:**<br>H (#6)<br>VH (#7)<br>**Confidence:**<br>VH (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- Varying value (from the value of low to the value of very high) throughout the stage<br>(A drop in the feeling of fun at the beginning of the stage, but increasing feeling at the end of the stage; Sustaining feeling of learning from the previous stage)<br>**For attention:**<br>- A high/very high attention towards the imagery throughout the stage<br>- A low attention towards feedback when it was given in the second task (#6)<br>- A very high attention towards the cognitive tool (#7)<br>(Maintaining value at the end of the stage)<br>**For cognitive curiosity:**<br>- Varying level of curiosity throughout the stage (from the level of low to the level of high)<br>(Preserving value at the end of the stage)<br>**For effort:**<br>- A high/very high value throughout the stage<br>(Sustaining value from the previous stage)<br>**For confidence:**<br>- A very high confidence throughout the stage<br>(Maintaining value from the previous stage) | **For long-term relevance:**<br>- Sustained the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Maintained the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Preserved/Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Sustained the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>L (#6)<br>VH (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>VH (#6 - #7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>VH (#7) | | | | |
| Imagery | | **Attention:**<br>H (#6)<br>VH (#7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>L (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table D.7: Case dynamic matrix 3: ‘The Second Task’ (snapshot 6 – snapshot 7) of case study 3

Table D.8 (column: How Issues in Matrix 3 Resolved) shows how the strategies previously described could be implemented in the game environment (considering our game prototype as an example). The ending of the story was revealed in order to sustain the participant’s feeling of fun as well as her confidence; also, it was expected to be able to preserve the high level of cognitive curiosity or to increase it to a very high level in this stage. The colourful scene (Emma’s house) was presented once again; the purpose in using this scene is to draw the participant’s attention and to preserve the very high level of effort used from the previous stage by influencing her to guess about the next event. As a result of this implementation, the values of most motivational states were reported to be high/very high in this stage except that of attention; however, this did not seem to have a strong impact on the participant's motivation since when she was asked to report her overall motivation at the end of the game, she reported to be motivated to both learn and play with the game environment which was the satisfying outcome.

| ILE Features | | Motivational States | | How Issues in Matrix 3 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:** VH | **Cognitive curiosity:** VH<br>**Effort:** H<br>**Confidence:** VH | **For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene - Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For long-term relevance:**<br>- A very high value throughout the stage (Sustaining value from the previous stage)<br>**For attention:**<br>- A very low attention paid to the imagery used in this stage (Small drop in value, but still in the positive level compares to the previous stage)<br>**For cognitive curiosity:**<br>- A very high level of curiosity in this last stage (Increasing curiosity from the previous stage)<br>**For effort:**<br>- A high level of effort used in this stage (Small drop in value, but still in the positive level compares to the previous stage)<br>**For confidence:**<br>- A very high confidence in this stage (Sustaining value from the previous stage) | - Resulted in satisfying outcome – the participant was finally motivated to learn with the game environment |
| G: Provide Fun | | **Long-Term Relevance:** VH | | | | |
| Content | | **Long-Term Relevance:** VH | | | | |
| | Cognitive Tool | **Attention:** AS | | | | |
| Imagery | | **Attention:** VL | | | | |
| | Feedback | **Attention:** AS | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table D.8: Case dynamic matrix 4: 'The Finale' (snapshot 8) of case study 3

### D.3.3 The Revised Causal Model

Figure D.4 presents the revised causal model of motivation of the case. The model demonstrates the ILE features, the motivational variables and the relationships among them in a form of network. The motivational variables and the ILE features are represented by nodes whereas the relationships among them are represented using links. The details about the links can be explained in the same way as in case study 1 (see section 7.3.3.3 for the explanation).

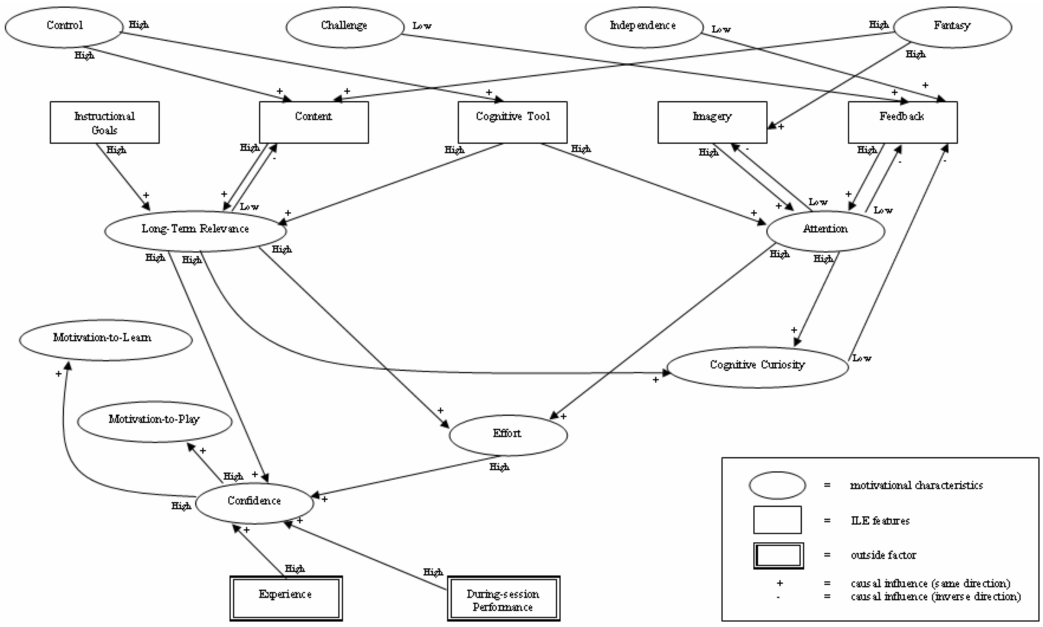


Figure D.4: The revised causal model of motivation of case study 3

The story of the model can be told as two related parts. The first part of the story explains the relationships between the trait characteristics of the participant (independent variables) and the features of the game ILE (dependent variables). The story of this part starts when the participant reported about her trait characteristics in a learning environment that she preferred to have control over the learning materials. But she did not like challenging situations and did not want to be independent when learning (she preferred to get some helps from a tutor when facing with difficult situations). Based on her report, she was assigned by MoRes to play Alex's Adventure 3.0 where she could have control over some parts of the game content and the cognitive tool (the tool can be considered as a part of the content as explained in case study 1). Furthermore, if the participant made a mistake during the tasks, she would be given the direct feedback that told her explicitly about what was wrong and what was supposed to be right. These design attempts to make the game better matched with the high-control, low-challenge and low-independent characteristics of the participant.

The second part of the story describes the relationships between the features of the game and the state characteristics of the participant (both of them can be viewed as both the independent and the dependent variables as explained in case study 1). The story of this part begins when the participant started the interaction with the game environment. According to the data (see Figure D.1 for the plot of attention, Figure D.2 for the plot of relevance and Figure D.3 for the plot of cognitive curiosity, effort and confidence), the fluctuations in the graphs exist in those plots which means the values of the participant's motivational states can vary according to the scenes presented. Certainly, there are some similarities and some differences among these scenes; thus, some of them may contain the same features and some of them may consist of different features. That is to say the features included in a single scene could play an important role in changes in the values of the motivational states. Thus, it was considered that the features of the game environment could exert some influences on the motivational states of the participant.

In general, the use of imagery as well as the use of the cognitive tool in the game ILE could attract the participant's attention instantly throughout the interaction; thus, two links were drawn from the features: imagery and cognitive tool, to attention to represent the relationship between these features and the attention state of the participant. However, there was a point in the game where the participant reported to pay low attention to the imagery (snapshot 8) and hence, another link was drawn backward from attention to the feature – imagery, in order to show that this feature could be adjusted to raise the attention level of the participant. As for the feature – feedback, the participant reported to pay low attention to this feature when it was given during both tasks in the game and as a result, a link was drawn backward from attention to this feature to demonstrate that the feedback could be changed in order to increase the attention level.

Furthermore, the participant reported to have a high feeling to learn from the game throughout the interaction and to have a high feeling of fun in general (see Figure D.2 for the plot of relevance). This shows the correspondence between the instructional goals (support learning and provide fun) and the goals of the participant in learning and having fun with the game. This correspondence can be regarded as long-term relevance since the goals of the participant were reported to occur from the beginning and to be preserved until the end of the game. Based on this, two links were drawn from the features: instructional goals and content to long-term relevance as shown in Figure D.4. From the figure, there is also another link drawn backward from long-term relevance to the feature – content, to demonstrate that the content of the game could be adjusted in order to raise the participant's feeling of fun when it dropped to a low level at some points in the game. As shown in Figure E.2 (the plot of relevance values which was measured against the features: instructional goals and content), the feelings that the game was relevant to his goal in learning were reported to be very high in snapshots 5 and 7 where the cognitive tool was presented. As a result, another arrow was drawn from the feature – cognitive tool, to long-term relevance to show the effect of the tool on the long-term relevance state of the participant.

On the other hand, the following motivational states: cognitive curiosity, effort and confidence, were considered to be affected by either attention or long-term relevance, or both, according to the literature described in section 4.2.3. Based on the literature and looking from the plot of cognitive curiosity, effort and confidence (Figure D.3), the plot of attention (Figure D.1) and the plot of relevance (Figure D.2), the value of cognitive curiosity at each point in the plot was considered to be driven by attention and long-term relevance. That is, when the value of attention and of relevance fall into the high-value area (Attention/Relevance Value = 4 and Attention/Relevance Value = 5), the value of cognitive curiosity also falls into the same area (Cognitive curiosity Value = 4 and Cognitive curiosity Value = 5). Based on this evidence and according to the literature described in section 4.2.3, two links were drawn from the motivational states: attention and long-term relevance, to cognitive curiosity to represent the relationships among them. However, as the participant reported to have a low level of cognitive curiosity when the feedback was given during the tasks, there is a link drawn backward from cognitive curiosity to the feature – feedback, in order to demonstrate that this feature could be adjusted in order to lift the level of her cognitive curiosity.

Similarly, the effort used in playing the game was likely to be influenced by attention and long-term relevance. From the comparison of the plots of these motivational states, there are similarities among these plots (the plots fall into the same area (the high-value area) in general) even though the values of these motivational states at some specific points in the game are not exactly the same. As a result, two links were drawn from attention and long-term relevance to effort in order to represent the relationships among them.

A slightly different explanation is made for confidence. According to the plot of cognitive curiosity, effort and confidence (Figure D.3), the plot of attention (Figure D.1) and the plot of relevance (Figure D.2), the values of confidence were likely to be influenced by long-term relevance and effort (even though the value of each of these motivational states is not exactly the same for every single point in the game, but in general, the values fall into the same area (the high-value area)). It was considered that the values of confidence at these points might be influenced by the outside factors (during-session performance and experience) similar to case study 1 and case study 2. According to the supplement data obtained from the participant, she had experiences in using some database software (Microsoft Access and Oracle) and she also enjoys playing computer games and video games in her leisure time. This might be reflected as a reason why the participant reported to have a high/very high level of confidence throughout the interaction with the game. Performance was also another factor that plays an important role in the confidence of the participant. As can be seen from Figure D.3, her confidence was reported to drop from a very high level to a high level in snapshot 3 where the tasks in the game were mentioned and in snapshot 4 in which the first task was presented. The drop in the confidence level of the participant might be because she did not feel confident whether she could do the tasks well in the first place; however, the participant could perform very well in the first task and thus, when the second task was presented, her confidence was reported to increase to a very high level once again. Based on the explanation so far, four links were drawn from long-term relevance, effort, experience and during-session performance to confidence in order to represent the relationship among them.

## D.4 Summary of Case Study 3

This case can be regarded as a normal 'motivated' case as the participant reported to feel motivated to learn after the interaction with the game was finished.

The participant was asked to provide the trait characteristics in a learning environment and based on her report, she was assigned by MoRes to play Alex's Adventure 4.0 which was considered to be the version of the game that suit with her traits. The trait characteristics of the case are shown in Table D.1. The participant was also asked to report about her motivational states during interaction with the game and her overall motivational states after she finished playing the game. The data regarding the motivational states of the case during interaction was presented using the event listing table (Table D.2) and the plots of motivational states (Figure D.1 – Figure D.3). The effects matrix of ILE features (Table D.3) was employed to describe the effects of the game features on the motivational states of the case. The causal mechanisms between the trait characteristics of the case, the features of the game and the state characteristics of the case were revealed using the explanatory effects matrix (Table D.4) and four case dynamics matrices (Table D.5 – Table D.8). The revised causal model of motivation of the case was also developed to present these causal mechanisms in a coherent picture (Figure D.4).

Some major findings can be drawn from the study of this case.

- To raise the level of attention, the features: imagery and feedback, could be adjusted (e.g. avoiding using the repetitive scene by making some changes to the scene if the scene was about to be used once again)
- To raise the level of cognitive curiosity, the feature – feedback, could be adjusted (e.g. summarising what the learner did instead of giving only a short praise)

- Since the participant reported to have a low feeling of fun when the activity/tasks (either academic-related or non-academic related task) in the game were given, the features – content, could be adjusted in order to increase her feeling of fun (e.g. changing the way in doing the task)
- Similar to the other cases, confidence was the motivational state that might be influenced by the outside factors: during-session performance and experience; however, it was not evident whether these factors could also have an influence on the other motivational states.

# Appendix E

# The Analysis of Case Study 4

This appendix presents the analysis of case study 4 (case E04). The analysis was done in a similar fashion compared to the other cases (case study 1 and case study 6 (chapter 7), case study 2 (Appendix C), case study 3 (Appendix D)).

# E.1 Background of Case Study 4

The participant is a male gender whose age is between 20-25 yeas old. He is an international student and he is doing his master degree in computing science. The participant has a reasonably good knowledge in database modelling and had experience in creating databases, but he didn't mention the name of the database software that he used. He enjoys playing computer games and has played several kinds of game e.g. role-playing game, puzzle game, etc. At the start of the session with our computer program – MoRes, the participant was asked to provide the data about some of his trait characteristics in a learning environment. These characteristics are shown in Table E.1.

Based on his trait characteristics, MoRes assigned him to play Alex's Adventure 2.0[1].

| Control | Challenge | Independence | Fantasy |
|---|---|---|---|
| High | High | Low | High |

Table E.1: Trait characteristics of case study 4

However, after the participant finished playing the game he reported not to be motivated to learn from it. Thus, he was asked to play the adjusted version of Alex's Adventure 2.0 (Alex's Adventure 6.0). The motivational data of the participant from the interaction with the two games are presented alongside each other in order to show changes in the values of the motivational states when playing the first and the second game, accordingly. As already mentioned in the analysis of case study 6 (chapter 7), the term 'first play' and 'second play' may appear in the following sections which refer to the time when the participant played the first game (Alex's Adventure 2.0) and the second game (the adjusted version of Alex's Adventure 2.0), respectively.

# E.2 Representations for Describing the Motivation of Case Study 4

## E.2.1 Event Listing of Motivational State

Table E.2 is a table of event listing which was created based on the data reported through the use of a retrospective self-report. The table aims at displaying the values of the motivational states of the case when playing the first game.

[1] The specifications of Alex's Adventure 2.0 were described in chapter 5 (section 5.3.1.4).

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Attention** | **Imagery** | H | VH | H | H | H | H | H | L |
| | **Feedback** | AS | AS | AS | L | AS | L | AS | AS |
| | **Cognitive Tool** | AS | AS | AS | AS | H | AS | N/A | AS |
| **Relevance** | **Content** | H | H | N/A | N/A | H | N/A | H | H |
| | **Goal: Support Learning** | H | L | N/A | N/A | N/A | N/A | N/A | H |
| | **Goal: Provide Fun** | VH | L | VH | L | N/A | L | N/A | H |
| **Cognitive Curiosity** | | VH | VH | H | L | H | L | H | H |
| **Effort** | | H | VH | VH | H | H | H | H | N/A |
| **Confidence** | | VH | VH | H | H | H | H | H | H |

| | | | |
|---|---|---|---|
| Legend: | VL | = | Very Low |
| | L | = | Low |
| | N/A | = | Not Applicable |
| | H | = | High |
| | VH | = | Very High |
| | AS | = | Absent feature from the scene |

Table E.2: Event listing of motivational state of case study 4 (first play)

Based on the data shown in the table and our observational notes, the participant seemed to be attracted to the beginning scenes used in the games since he stared at the scenes all the time and moved his top body closer to the screen when reading the introduction to all characters in the ‘Invitation’ scene. He also looked curious to start playing the game as he clicked the button ‘Play Game’ immediately. When the participant was presented with the ‘In the Forest’ scene, he seemed to pay attention to the conversation between the characters appeared in the scene. Furthermore, when he was asked to find all hidden mushrooms in the forest in order to progress through the next scene, he looked curious and made an effort in finding the mushrooms (looked over the screen **(:G1)**). After he finished collecting the mushrooms and saw the scene was changing, he seemed to feel satisfied **(:F1)**. When the participant was presented with the next scene, his attention was likely to be drawn by the appearance of the other two characters – Dr de Ville and Mary and he seemed to feel interested in the conversation among the characters appeared in this scene (seemed to think along **(:G2)**). In the subsequent scene – the ‘First Task’ scene, the participant was likely to be attracted by objects and dialog boxes describing the scenario of the task and how to do it **(:G1)**. Also, he seemed to be highly concentrated when doing the task (checked the information kept in each chest before choosing which one he was going to move **(:G3)** and some chests were checked several times **(:G4)**). The participant finished the task without making any mistake and looked satisfied **(:F1)**. In the ‘Meet Mushyman #1’ scene the participant was likely to be attracted by the appearance of the character, Mushyman and seemed to concentrate on its explanation about the knowledge embedded in the task (move the mouse along the explanation **(:G5)**). In the following two scenes (the ‘Second Task’ scene and the ‘Meet Mushyman #2’ scene) where the participant was asked to do the second task and was presented with the explanation about the task, his responses were similar to when he did the first task and met Mushyman for the first time. When the last scene was presented, the participant seemed to pay attention to what was going to happen in the scene as he moved the main character to Emma's house (the place where the whole story began) without bothering to wander around.

Similarly, Table E.3 was created in order to display the values of the participant's motivational states when playing the second game.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Attention** | **Imagery** | H | VH | N/A | VH | H | H | H | H |
| | **Feedback** | AS | AS | AS | H | AS | L | AS | AS |
| | **Cognitive Tool** | AS | AS | AS | AS | H | AS | H | AS |
| **Relevance** | **Content** | H | H | H | H | VH | H | VH | H |
| | **Goal: Support Learning** | H | N/A | H | H | VH | H | VH | VH |
| | **Goal: Provide Fun** | H | L | VH | H | VH | H | VH | VH |
| **Cognitive Curiosity** | | H | H | VH | N/A | H | L | H | H |
| **Effort** | | VH | H | H | VH | H | VH | H | H |
| **Confidence** | | VH | VH | H | VH | H | VH | VH | H |

Legend:
VL = Very Low
L = Low
N/A = Not Applicable
H = High
VH = Very High
AS = Absent feature from the scene

Table E.3: Event listing of motivational state of case study 4 (second play)

Comparing the data from the second play to the first play, the participant seemed to have a lower feeling of fun and to feel less curious towards the beginning scenes. When the participant was presented with the 'In the Forest' scene, he reported to have a lower level of curiosity about what was going to happen; he also reported to use a lower level of effort in doing the task which might be because he could remember, from the first game, how to complete this task. In the next scene where the tasks in the game were mentioned, the participant reported to have a suspicion that the tasks might be relevant to learning some concepts in ERM and felt curious how they would be different from those in the first game. When the participant was presented with the 'First Task' scene where the obvious changes were made, the values of most motivational states were reported to increase except that of cognitive curiosity in which the participant was not able to report the value. In the 'Meet Mushyman #1' scene the participant reported to have a very high feeling to learn from the game and a very high feeling of fun. The same report happened once again when the participant was presented with the second task and the explanation about the task. In addition, the confidence level of the participant was reported to be very high when he was in the 'Second Task' scene and the 'Meet Mushyman #2' scene. In the last scene his feeling to learn and his feeling of fun were continuously reported to be at a high level.

### E.2.2 Plot of Motivational State

Six plots of motivational state were developed. The first two plots (Figures E.1 and E.2) are the plots of attention in the first and the second play. The next two plots (Figures E.3 and E.4) are the plots of relevance in the first and the second play and the last two plots (Figures E.5 and E.6) are the plots of three motivational states: cognitive curiosity, effort and confidence, in the first and the second play.

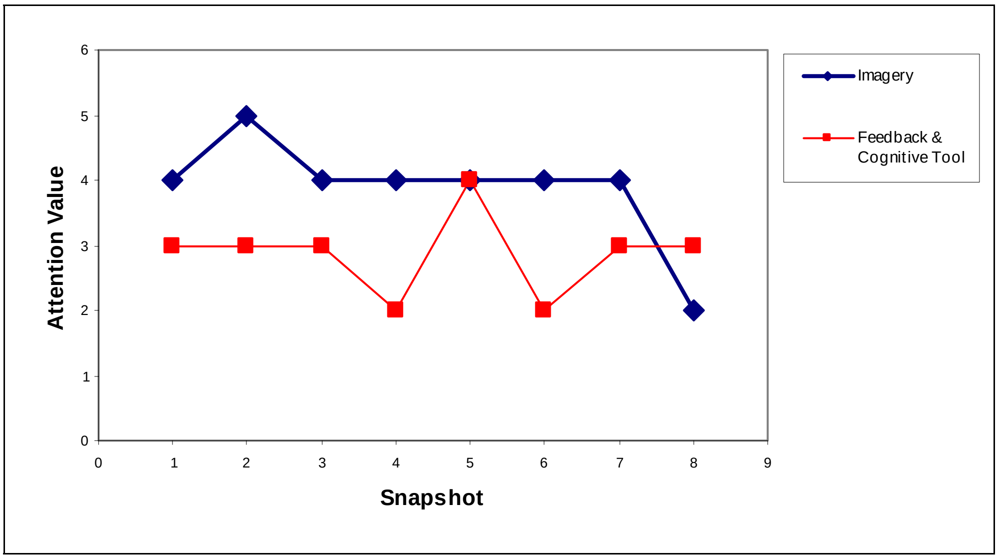


Figure E.1: Attention value towards three features of the game during the first play

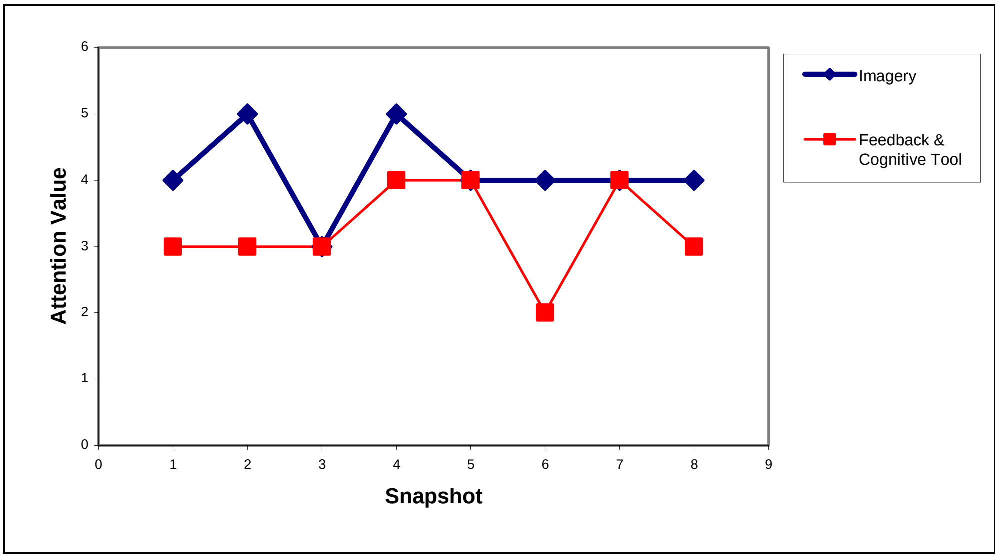


Figure E.2: Attention value towards three features of the game during the second play

Figures E.1 and E.2 show the values of the participant's attention towards three features of the game (imagery, feedback and cognitive tool) in the first and the second play, respectively. It can be seen from the figures that the participant was attracted to the imagery used in the first game as his attention was reported to be high/very high (Attention Value = 4 and Attention Value = 5) throughout the interaction except in the last scene where the participant reported to pay less attention (Attention Value = 2) which might be because the repetitive scene was used once again. Similarly, in the second game the participant was likely to pay the same level of attention as when he played the first game; however, in the scene where the evident changes were made to the imagery (snapshot 4) the participant reported to be instantly attracted by those changes, but this did not seem to be the case for the other scene where there was a similar change in the imagery (snapshot 6).

In general, when comparing the graph of attention in the first play to that in the second play, it looks like the participant paid similar level of attention to the imagery used in both games. As for the feature – feedback, the participant reported to pay low attention to this feature given in both tasks of the first game; however, in the second game he reported to pay high attention to this feature given in the first task (which might be because the changes in the imagery used in the task made the game look harder and the participant might feel curious whether each choice he made was correct; however, this did not seem to be the case when he did the second task (which might be because he could perform the first task very well and he might feel familiar with the task environment already). As for the feature – cognitive tool, the participant reported to pay high attention to this feature whenever it appeared in the second game; this might be because the participant was highly attracted to the changes made to the tasks in the second game which resulted in a higher level of attention paid to the cognitive tool as it related to the tasks and it was presented right after each task was finished.

Figures E.3 and E.4 show the participant’s feelings of relevance towards two features of the game: instructional goals (support learning and provide fun) and content in the first and the second play, respectively. According to the figures, the participant seemed to have the goal to learn from playing the game since he reported to feel interested in the database knowledge embedded in the game at the start of the first game (Relevance Value = 4 in snapshot 1) which shows his high feelings that the game, to some extent, was related to his needs. However, as the participant progressed through the game, he reported not to be able to tell about these feelings (the graph of his feelings that the instructional goal: support learning, was relevant to him is generally stable at the value of not applicable (Relevance Value = 3) throughout the game). On the contrary, when the participant was asked to play the second game (the adjusted version of the first game), it can be seen from the graph that the goal of the participant in learning existed and was fulfilled throughout the interaction with the game (the graph generally falls into a positive-value area (Relevance Value = 4 or Relevance Value = 5).

As for the participant's feeling of fun, the graph showing this feeling in the first game varies strongly between the value of very high and of low at the beginning of the game (snapshot 1 to snapshot 3). However, when it came to the serious part[2] of the game (snapshot 4 to snapshot 7), the graph fluctuates between the value of low and of not applicable before rising to the high level once again at the end of the game (snapshot 8). On the other hand, the graph showing this feeling in the second game falls into the positive-value area (Relevance Value = 4 or Relevance Value = 5) most of the time. Based on these graphs, the second game seemed to be more satisfied to the participant and it looks like the goal of the participant in having fun existed and was preserved throughout the game.

As for the content of the game, it was considered that the second game (compared to the first game) could fulfil his goal in learning and could satisfy his feeling of fun since the graph showing his feelings that the content of the second game was relevant to his goal falls into the high-value area throughout the interaction while the graph of his feeling of fun in the first game rather fluctuates between the value of high and of not applicable.

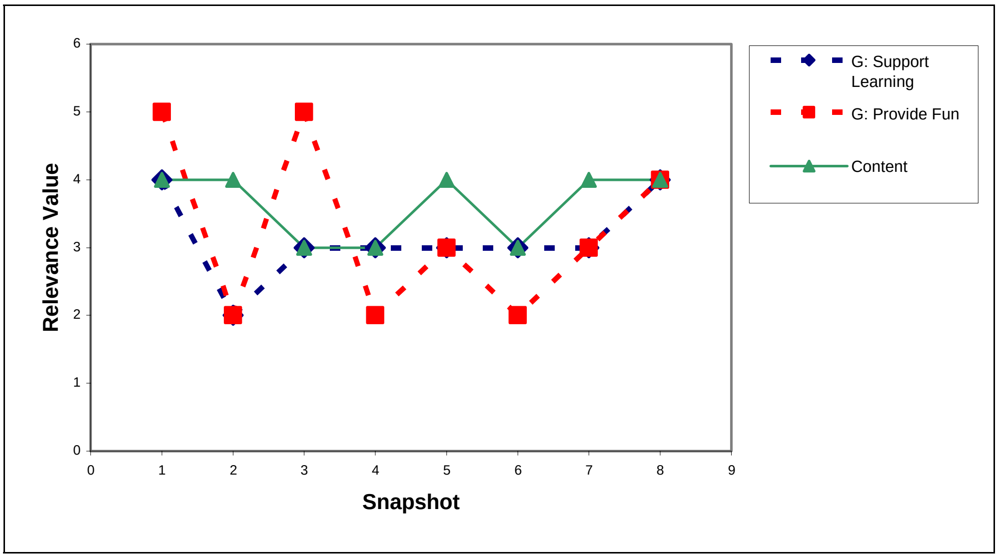


Figure E.3: Relevance value towards two features of the game during the first play

[2] The serious part of the game refers to the part that involves with the ERM knowledge (the tasks in the game (snapshot 4 and snapshot 6) and the explanations about the embedded knowledge (snapshot 5 and snapshot 7).

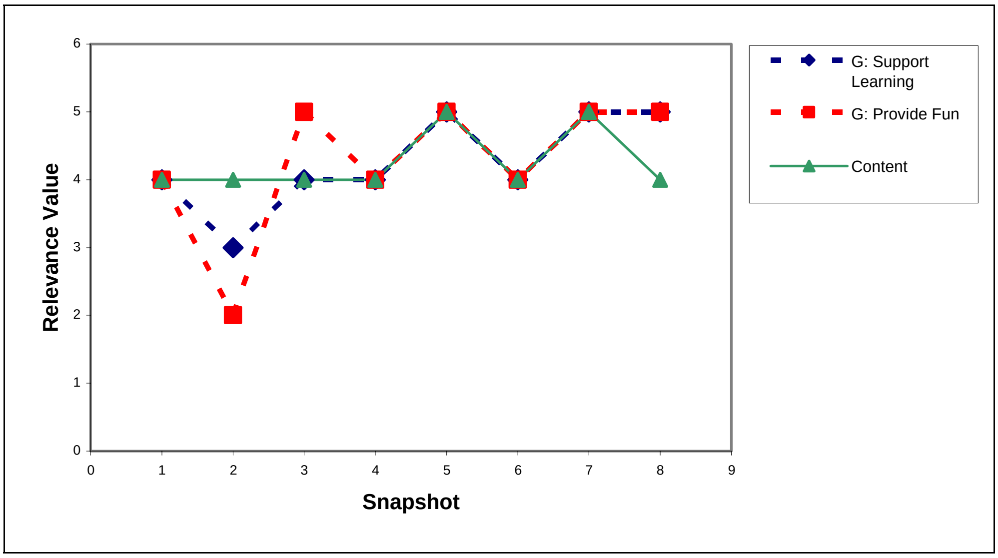


Figure E.4: Relevance value towards two features of the game during the second play

Figures E.5 and E.6 show the values of the following motivational states during interaction with both games: cognitive curiosity, effort and confidence. According to the figures, the participant reported to have a high level of cognitive curiosity throughout the first game (Cognitive Curiosity Value = 4 and Cognitive Curiosity Value = 5) except when he was doing the tasks in the game (snapshots 4 and 6) where he reported to have a low curiosity when the feedback were given. Similar to the first game, the participant reported to have a high level of cognitive curiosity throughout the second game. However, the values of this motivational state were reported to drop at some points during the second game (snapshots 1 and 2); the drop might be because it was the second play for the participant and the game did not change much from the first game and thus, he might feel familiar with the environment from the first play already.

As for the effort state, the participant reported to use a high effort in playing both games. However, he reported to use a higher level of effort in the non-serious part[3] of the first game (snapshots 2 and 3) compared to that of the serious part of the game. However, this did not seem to be the case when the participant played the second game as he reported to use a very high effort in the scenes where the explanations about the knowledge embedded in the tasks were given instead (snapshots 5 and 7). Also, he reported to use a very high effort at the start of the second game which might be because he tried to figure out how the second game would be different from the first game.

[3] The non-serious part of the game refers to the part that is not involved with the ERM knowledge (snapshot 1, snapshot 2, snapshot 3 and snapshot 8).

As for the confidence state, the participant reported to have a high level of confidence when playing both games; however, his feeling of confidence was reported to be higher in the second game, especially in the serious part of the game.

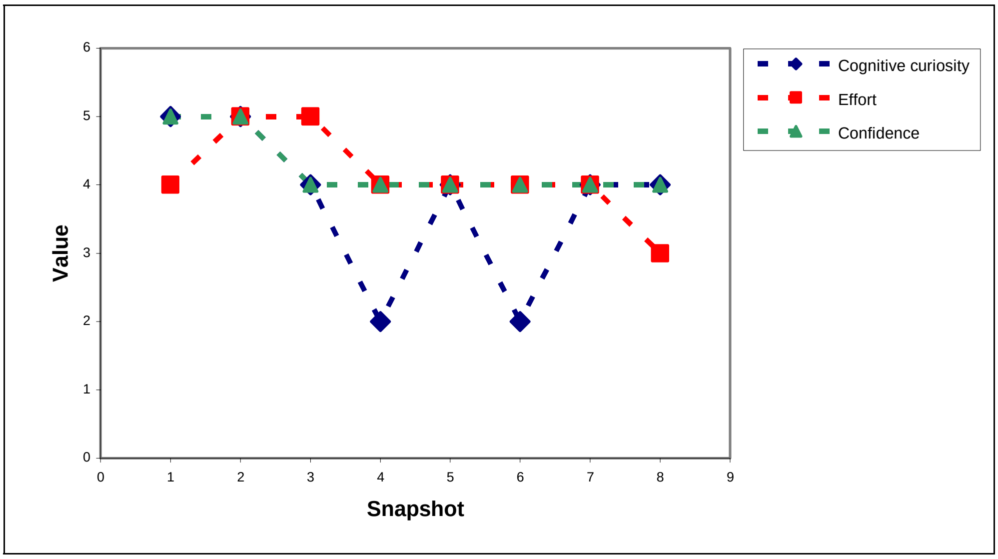


Figure E.5: The value of cognitive curiosity, of effort and of confidence during the first play

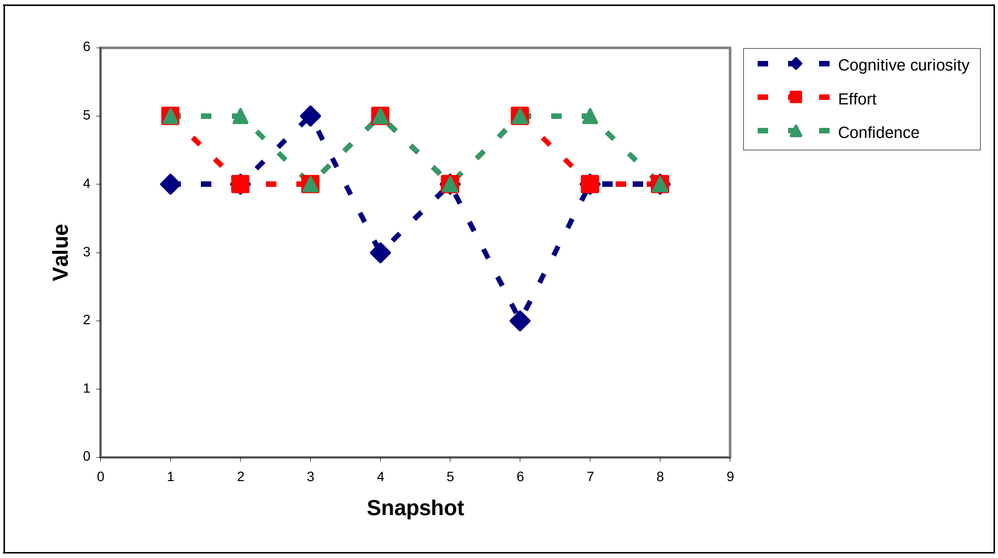


Figure E.6: The value of cognitive curiosity, of effort and of confidence during the second play

## E.2.3 Effects Matrix of ILE Features

Table E.4 was created aiming to describe the effects of game features on the motivational states of participant in the first and the second play. The table displays five features that make up the game ILE and three kinds of effects considered to be caused by these features. Similar to case study 6, a single table was built. The description of the table (below) was created based on existing literature as described in chapter 4 (section 4.2.3) and evidences (data from post-questionnaire, self-report, observational notes and semi-structured interview).

| **ILE Features** | **Direct Effects** | | **Meta Effects** | | **Side Effects** |
|---|---|---|---|---|---|
| | + | - | + | - | + |
| Imagery | Attracted the attention of the participant straight away | Not able to report about the attention in some scenes | Curious about the subsequent scene | | |
| Feedback | Highly attracted the participant’s attention regarding his performance when doing the second task in the game | | A high interest in receiving some feedback when doing the second task | | |
| Cognitive Tool | Paid very high attention to the immediate appearance and the explanations about both tasks | | Curious about how the tasks were relevant to databases | | |
| Content | Interested in the storyline of the game and the relevance between the game and the embedded knowledge | | Wanted to find out how the story would end and how the game were relevant to databases | | Widen the participant’s view about learning databases in a new environment other than a classroom setting |
| Instructional goals | Wanted to have fun and to learn and the game could fulfil the feelings | | | | |

Sources: Post-questionnaire, retrospective self-report, observational notes and semi-structured interview

Table E.4: Effects matrix of ILE features of case study 4

According to the table, the use of the imagery in both games could attract the attention of the participant straight away and it could make him felt curious about the subsequent scenes. In addition, when the participant played with the adjusted version (the second game), he reported to pay very high attention to the scene where the imagery was evidently changed. When the participant was given the feedback during the tasks in the first game, he reported not to pay much attention; he also felt less curious about its content as he always received the same feedback (short praises) in both tasks. However, in the second game the participant reported to pay high attention and to feel curious to the feedback given during the first task; this might be because the task was changed in such a way that made it more difficult and thus, he might want to know whether each choice he made was correct; however, this did not seemed to be the case in the second task which might be because he felt more confident after completing the first task. When the cognitive tool was presented after the first task in the first game was finished, the participant reported to feel attracted to its appearance and to feel curious about its explanation; however, this did not seem to be the case when it appeared again after the second task. This is rather different from the second game as the attention of the participant was reported to be drawn by the tool whenever it appeared and his curiosity was also reported to be high. As for the content of the game, the participant reported to feel interested in the storyline of the game as he felt curious about how the story would end and how the game was relevant to learning databases. In addition, when the participant played the second game, he reported to feel highly curious about the story, specifically, how it was different from that in the first game. After the participant finished playing the second game, he reported that the game and the tasks are well-designed and he noticed some improvements in the second game which gave him a strong impression. Furthermore, the concept oft entity and attribute in the tasks was made more obvious compared to that in the first game and this widen his view about learning databases in a new environment other than a classroom setting.

## E.3 Representations for Explaining the Motivation of Case Study 4

### E.3.1 Explanatory Effects Matrix

Tables E.5 and E.6 are tables of explanatory effects matrix which were created aiming to display the overall picture of the relationships among trait characteristics, ILE features and state characteristic in the first and the second play, respectively. Similar to the other case studies, the explanation of the table was created based on existing literature (see section 4.2.3) and evidences (data from post-questionnaire and self-report) which were considered to support the literature to some degree.

Table E.5 can be explained in the following manner. The participant reported about his trait characteristics in a learning environment that he preferred to have a high control and he enjoyed challenging situations. However, he did not want to be entirely independent when learning. Based on his report, he was assigned by MoRes to play Alex's Adventure 2.0. In this version of the game the participant could have control over the features: content and cognitive tool. That is, he could select which storehouse/wagon he preferred to start working with when doing each task in the game (content). He also could choose whether to receive an explanation from Mushyman after finishing each task (cognitive tool). Furthermore, if he made a mistake during the tasks, he would receive the guided feedback informing implicitly about what was supposed to be right. However, the participant reported not to be motivated to learn at the end of this game, and thus, he was asked to play the adjusted version of Alex's Adventure 2.0 (Alex's

Adventure 6.0) which is similar to the original version except that some changes were made to the imagery (see section 5.3.1.4 for more details on the changes).

As can be seen from the table, two instructional goals (support learning and provide fun) were seen as having effects on the long-term relevance state of the participant directly. Based on the data (see Figure E.2 for the plot of relevance in the first play), the participant seemed to have the goals to learn and to have fun with the game at the beginning of the first game as he reported to feel interested in the database knowledge embedded in the game and the game itself. However, as he progressed through the game, he was not able to report whether he gained knowledge from playing it. On the other hand, his goal in having fun was likely to be fulfilled as at the end of the game he reported that generally, he felt happy when playing the game.

Content which refers to the story and the knowledge embedded in the game is the feature that was also considered to have a direct effect on the long-term relevance. When looking at the plot of relevance (Figure E.2), it was considered that the content of the game could satisfy the participant's feeling of fun as he reported to have a high feeling that the content was relevant to his need in having fun when playing the game in general. Furthermore, he reported to be able to perceive the database knowledge embedded in the game, but it is difficult to infer whether his perception of knowledge could satisfy his interest in learning from the game since the participant reported not to be able to report the feelings whether the game could satisfy his interest when playing the serious-part of the game.

On the other hand, cognitive tool, feedback and imagery are the features which were considered to have a direct effect on the attention state of the participant. According to the plot of attention (Figure E.1), the participant paid a high level of attention to the imagery used in the game throughout the interaction except in the last snapshot where the repetitive scene was used. The use of cognitive tool to explain the knowledge embedded in the task could also draw his attention when it appeared after the first task was finished (snapshot 5); however, the participant was not able to report his attention paid to this feature when it appeared again after the second task (snapshot 7). As for the feedback, the participant reported to pay low attention to this feature when it was given in both tasks as they were similar.

Apart from causing the direct effect as explained earlier, the features were also considered to cause the meta effects. Three motivational states were considered to be the meta effects caused by the ILE features: cognitive curiosity, effort and confidence. According to the data (see Figure E.3 for the plot of cognitive curiosity, effort and confidence in the first play), the values of cognitive curiosity, generally, were reported to be at a high level throughout the game except when he was doing the tasks (a low curiosity was reported due to the similar feedback given in both tasks). Furthermore, it was noticed that the values of cognitive curiosity, to some extent, were influenced by attention and long-term relevance. As can be seen from the plot of these motivational states, there are some similarities at some specific points of these plots. For example, in the first snapshot the value of cognitive curiosity seems to be influenced by the value of relevance towards the instructional goal: provide fun, whereas in the fifth snapshot the value of cognitive curiosity is likely to be influenced by the value of attention towards the imagery and the cognitive tool. According to this and the literature in section 4.2.3 that described the plausible order of the motivational states appeared in the preliminary model (see section 4.2.3), it was considered that cognitive curiosity is the motivational state that seemed to be affected after attention and long-term relevance.

As for the effort state, the participant reported to use a high effort from the start to the end of the game in general. Similar to cognitive curiosity, some similarities were noticed among the plot of attention, the plot of relevance and the plot of effort in the first play (Figure E.1, Figure E.2 and Figure E.3, respectively). A high effort was reported to be used when the participant was attracted to the game (e.g. snapshot 2) or when he felt the game was relevant to his intention to have fun when playing the game (e.g. snapshot 3). Thus, effort was also regarded as the motivational state that seems to be affected after attention and long-term relevance based on this piece of information and the literature in section 4.2.3.

The similar explanation can be made for the confidence state of the participant. As can be seen from the plot of confidence in the first play (Figure E.3), the participant reported to have a high level of confidence throughout the interaction with the game. He reported feeling very confident at the beginning of the game (snapshots 1 and 2). His confidence decreased slightly to a high level when he was told that he needed to do some tasks in the game (snapshot 3) and the confidence remained stable at this level until the end of the game. Similar to cognitive curiosity and effort, there are some similarities among the plot of attention, the plot of relevance and the plot of confidence. For instance, in the first snapshot the participant reported to have a very high feeling of fun and felt highly confident to start playing the game. According to this and the literature in section 4.2.3, confidence was also considered to be the motivational state that seemed to be affected after attention and long-term relevance.

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state): Direct Effects | Short-Run Effects (process perspective on state): Meta Effects | Longer-Run Consequences (overall-state perspective): Initial States | Longer-Run Consequences (overall-state perspective): Consecutive States |
|---|---|---|---|---|---|---|
| | Instructional goal: Support Learning | | **Long-Term Relevance:** Likely to have the goal in learning at the beginning of the game, but difficult to tell whether this goal had been satisfied throughout the game (as mostly, the participant reported to have the 'N/A' value for the feelings of relevance) | **Cognitive curiosity:** A high curiosity in general except when the feedback was given during the tasks **Effort:** Sustaining high level of effort used in playing the game in general **Confidence:** Maintaining high level of confidence throughout the game in general | **Long-Term Relevance:** H | **Cognitive curiosity:** H **Effort:** H **Confidence:** H |
| | Instructional goal: Provide Fun | | **Long-Term Relevance:** Another goal that seemed to exist from the beginning and was likely to achieved throughout the game | | **Long-Term Relevance:** H | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Long-Term Relevance:** Difficult to tell whether the participant perceive the database knowledge in the first task; generally, felt fun throughout the game, but less fun was reported in the scenes where the tasks were given | | **Long-Term Relevance:** VH | |
| | Cognitive Tool | Can choose not to receive the explanations from Mushyman | **Attention:** Caught the attention of the participant by the immediate appearance of the tool and its explanations | | **Attention:** H | **Cognitive curiosity:** H **Effort:** H **Confidence:** H |
| Challenge | Feedback | Guided feedback | **Attention:** Paid less attention to the feedback given during the tasks in the game due to the use of the same feedback style | | **Attention:** H | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** Attracted the participant's attention instantly most of the time except when the scene was used repeatedly | | **Attention:** H | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Felt the coherency in the storyline and perceived the knowledge embedded in the story after receiving the explicit explanations | | **Long-Term Relevance:** VH | **Cognitive curiosity:** H **Effort:** H **Confidence:** H |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.5: Explanatory effects matrix of case study 4 (first play)

The causality among trait characteristics, ILE features and state characteristic in the second play can be explained in a similar way. However, some differences exist between the first play and the second play. The imagery used in the adjusted game was changed and these changes had a strong impact on the attention of the participant. As can be seen from the plot of attention which was measured against the imagery (see Figure E.1), his attention was driven to a very high level in the scene where the change was made (snapshot 4). Also, the participant reported to have a high feeling to learn from this game which resulted from these changes. This evidence was considered to strengthen our preliminary model in that attention and long-term relevance were the motivational states that can be directly affected by the features of the game.

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state) | | Longer-Run Consequences (overall-state perspective) | |
|---|---|---|---|---|---|---|
| | | | **Direct Effects** | **Meta Effects** | **Initial States** | **Consecutive States** |
| | Instructional goal: Support Learning | | **Long-Term Relevance:** Likely to have the goal in learning from the beginning of the game and this goal seemed to be achieved throughout the game | **Cognitive curiosity:** A high level of curiosity in general except when the feedback was given during the tasks **Effort:** Sustaining high level of effort used in playing the game in general **Confidence:** Maintaining high level of confidence throughout the game in general | **Long-Term Relevance:** H | **Cognitive curiosity:** VH **Effort:** H **Confidence:** H |
| | Instructional goal: Provide Fun | | **Long-Term Relevance:** Another goal that seemed to exist from the beginning and was likely to achieved throughout the game | | **Long-Term Relevance:** H | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Long-Term Relevance:** A higher feeling of learning with the second game (the adjusted version of the first game) | | **Long-Term Relevance:** VH | |
| | Cognitive Tool | Can choose not to receive the explanations from Mushyman | **Attention:** Caught the attention of the participant by the immediate appearance of the tool and its explanations | | **Attention:** H | **Cognitive curiosity:** L(feedback)/H **Effort:** H **Confidence:** H/VH(feedback) |
| Challenge | Feedback | Guided feedback | **Attention:** Paid high attention to the feedback given during the first task in the game, but less attention was paid to the feedback during the second task due to the use of the same feedback style | | **Attention:** L | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** Attracted the participant's attention instantly throughout the game, especially in the scenes where some changes were made | | **Attention:** H | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Felt the coherency in the storyline and highly perceived the knowledge embedded in the story | | **Long-Term Relevance:** VH | **Cognitive curiosity:** VH **Effort:** H **Confidence:** H |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.6: Explanatory effects matrix of case study 4 (second play)

## E.3.2 Case Dynamics Matrix

Tables E.7, E.8, E.9 and E.10 were developed aiming to display how the features of the first game cause changes in the values of the participant's motivational states.

As shown in Table E.7 (column: Underlying Issues (as seen by us)), the participant reported to pay high attention to the imagery used in the first stage ('The Prelude'). Also, he reported to feel interested to learn at the beginning of the stage; however, the feeling was reported to decrease at the middle of the stage and the participant was not able to report the feeling at the end of the stage when he was told that he had to do some tasks in order to complete the mission of the game. According to his report, it looks like his goal in learning slipped away as he reported not to have any suspicion that the tasks mentioned at the end of the stage might relate to learning some concepts in ERM. Furthermore, he reported to have a very high feeling of fun at the beginning and at the end of the stage, but the feeling was reported to drop to a low level when he was asked to do the task at the middle of the stage in order to progress through the next stage. As for cognitive curiosity, effort and confidence, the participant reported to have a high level of cognitive curiosity throughout the stage. He also reported to use a high effort when playing the game at this stage and felt very confident that he could play the game well. According to his report, the strategies were specified in order to deal with these issues as shown in the column: How to Cope with. It was considered that the game could maintain/raise the level of attention by using more colourful graphics in the following scenes. The very high feeling of fun of the participant could be sustained by including more fun elements (such as surprised events or interactive activities) in the consecutive scenes. The feeling to learn of the participant could be increased and to achieve this, the knowledge embedded in the game was considered to be presented in the subsequent scenes. The presentation of the knowledge was also expected to be able to preserve/increase the high level of cognitive curiosity and to keep the very high level of effort used from this stage to the next stage. In addition, the game could consider sustaining/raising the high level of confidence of the participant through the next stage.

| ILE Features | | Motivational States | | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#1)<br>L (#2)<br>N/A (#3) | **Cognitive curiosity:**<br>VH (#1 - #2)<br>H (#3)<br>**Effort:**<br>H (#1)<br>VH (#2 - #3)<br>**Confidence:**<br>VH (#1 - #2)<br>H (#3) | **For long-term relevance:**<br>- A high/very high value at the start of the stage (#1)<br>- A low value when the participant was asked to complete a task (#2)<br>- Not able to tell about the feeling of learning at the end of the stage (#3)<br>- A very high feeling of fun at the end of the stage (#3)<br>**For attention:**<br>- A high/very high value throughout the stage<br>**For cognitive curiosity:**<br>- A high/very high value throughout the stage<br>**For effort:**<br>- A high/very high value throughout the stage<br>**For confidence:**<br>- A high/very high value throughout the stage | **For long-term relevance:**<br>- Sustained/Increases the feelings of long-term relevance by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>**For attention:**<br>- Maintained/Raised the level of attention by using more colourful graphics in the following scenes<br>**For cognitive curiosity:**<br>- Preserved/Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept the level of effort by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Sustained/Raised the level of confidence by making use of the feature: content |
| G: Provide fun | | **Long-Term Relevance:**<br>VH (#1, #3)<br>L (#2) | | | |
| Content | | **Long-Term Relevance:**<br>H (#1 - #2)<br>N/A (#3) | | | |
| | Cognitive Tool | **Attention:**<br>AS (#1 - #3) | | | |
| Imagery | | **Attention:**<br>H (#1, #3)<br>VH (#2) | | | |
| | Feedback | **Attention:**<br>AS (#1 - #3) | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.7: Case dynamic matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 4 (first play)

In the second stage (‘The First Task’) our game prototype was unfolded[4] in order to show how the strategies explained in the previous matrix could be implemented in the

[4] The term ‘unfold’ refers to the use of our game prototype as an example that implemented the anticipated changes in the game features according to the specified strategies.

game environment as can be seen from Table E.8 (column: How Issues in Matrix 1 Resolved). The first task was given to the participant and the explanation about the embedded knowledge was also provided after the task was finished. The revelation of the task and the explanation aimed at sustaining the participant's feeling of fun and increasing his feeling to learn. Also, it aimed at preserving/increasing the high level of cognitive curiosity and keeping the very high level of effort used from the previous stage. During the task the participant was given the feedback relating to his performance (a short praise was given for every correct choice and a guided feedback was given for the wrong choices). The feedback aimed at sustaining/raising his high level of confidence in this stage. Furthermore, the colourful scenes and the funny look of cognitive tool were used to maintain/raise the attention level of the participant. As a result of this implementation, the values of the motivational states were reported to be changed as can be seen from the column: Underlying Issues (as seen by us). The participant was still not able to report the feeling to learn throughout the stage. He reported to feel less fun when doing the task and was not able to report whether he satisfied with the explanation about the embedded knowledge given by the cognitive tool. Furthermore, he reported to pay low attention to the feedback given during the task. However, he reported to be attracted by the imagery used at this stage of the game and by the funny look of the cognitive tool. As for cognitive curiosity, effort and confidence, the participant reported to have a high curiosity when the explanation was given by the cognitive tool. The high level of effort was reported to be used throughout the stage and he felt confident when playing at this stage of the game. Based on these issues, the strategies were specified as appeared in the column: How to Cope with. Another task was considered to be given to raise the participant's feeling to learn and his feeling of fun; the task would be slightly different from the previous task, but would not be exceedingly difficult in order to sustain/increase the high level of confidence and of effort used in playing the game through the next stage. Also, the second task aimed at preserving/increasing the high level of cognitive curiosity of the participant which was reported at the end of the stage. In addition, the imagery used in the second task could be changed to maintain/raise his high level of attention through the next stage.

| ILE Features | | Motivational States | | How Issues in Matrix 1 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>N/A (#4 - #5) | **Cognitive curiosity:**<br>L (#4)<br>H (#5)<br>**Effort:**<br>H (#4 - #5)<br>**Confidence:**<br>H (#4 - #5) | **For long-term relevance:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For attention:**<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>**For cognitive curiosity:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For effort:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4) | **For long-term relevance:**<br>- Not able to tell about the feeling of learning throughout the stage<br>- A low feeling of fun when doing the task in the game (#4)<br>- Not able to tell about the feeling of fun when the explanation about the task was given (#5)<br>(A drop in the feeling of fun in this stage)<br>**For attention:**<br>- A high attention towards the imagery throughout the stage<br>- A low attention towards feedback when it was given during the task (#4)<br>- A high attention towards the cognitive tool (#5)<br>(Sustaining value at the end of the stage)<br>**For cognitive curiosity:**<br>- Varying level of curiosity throughout the stage (from the level of low to the level of high)<br>(Maintaining value at the end of the stage)<br>**For effort:**<br>- A high level of effort used throughout the stage<br>(Small drop in value, but still in the positive level)<br>**For confidence:**<br>- A High confidence throughout the stage<br>(Preserving value from the previous stage) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by giving another task to do<br>**For attention:**<br>- Maintained/Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Preserved/Increased the level of curiosity by giving another task which should be slightly different from the first task<br>**For effort:**<br>- Kept/Raised the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>**For confidence:**<br>- Sustained/Increased the level of confidence by giving another task which should not be too hard compared to the first task |
| G: Provide Fun | | **Long-Term Relevance:**<br>L (#4)<br>N/A (#5) | | | | |
| Content | | **Long-Term Relevance:**<br>N/A (#4)<br>H (#5) | | | | |
| Cognitive Tool (#5) | Cognitive Tool (#4) | **Attention:**<br>AS (#4)<br>H (#5) | | | | |
| Imagery | | **Attention:**<br>H (#4 - #5) | | | | |
| Feedback (#4) | Feedback (#5) | **Attention:**<br>L (#4)<br>AS (#5) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.8: Case dynamic matrix 2: ‘The First Task’ (snapshot 4 – snapshot 5) of case ctudy 4 (first play)

Table E.9 (column: How Issues in Matrix 2 Resolved) shows how the strategies explained earlier could be implemented in the game environment (considering our game prototype as an example). The participant was given the second task and the explanation about the knowledge embedded in the task. The task aimed at increasing the feeling to learn and his feeling of fun. It was also expected to be able to preserve/increase the high level of cognitive curiosity and of effort from the previous stage. Similar to the first task, the participant was given the feedback concerning his performance when doing the task in order to sustain/raise the confidence level. The scene theme was also changed to maintain/increase his high level of attention from the previous stage. The implementation resulted in changes in the values of the participant’s motivational states as shown in the column: Underlying Issues (as seen by us). Still, the participant reported not to be able to tell about the feeling to learn from the game. Similar to the previous stage, the participant reported to have a low feeling of fun and was not able to report his enjoyment when he was given the explanation about the task. However, he reported to be attracted by the imagery used in this stage of the game, but not to the funny look of the cognitive tool. Again, he reported to pay less attention to the feedback given during the task. As for cognitive curiosity, effort and confidence, the same values as those in the previous stage were reported. According to these issues, the strategies were specified as shown in the column: How to Cope with. It was considered that the game could increase the participant's feeling to learn and his feeling of fun and could sustain/increase his high level of cognitive curiosity, of effort and of confidence through the next stage. In order to achieve this, the feature: content, was exploited. Two choices were considered in making use of this feature: offering a new task or continuing the story. It was considered that continuing the story seems to be the more proper way (see section 7.3.3.2 for the same explanation as given for case study 1). In addition, the feature – imagery, was exploited in order to maintain/raise the high level of attention of the participant.

| **ILE Features** | | **Motivational States** | | **How Issues in Matrix 2 Resolved:** | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>N/A (#6 - #7) | **Cognitive curiosity:**<br>L (#6)<br>H (#7)<br>**Effort:**<br>H (#6 - #7)<br>**Confidence:**<br>H (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- Not able to tell about the feeling of learning throughout the stage<br>- A low feeling of fun when doing the task in the game (#6)<br>- Not able to tell about the feeling of fun when the explanation about the task was given (#7)<br>(Remaining low feeling of fun in this stage)<br>**For attention:**<br>- A high/very high attention towards the imagery throughout the stage<br>- A low attention towards feedback when it was given in the second task (#6)<br>- Not able to tell about the attention level towards the cognitive tool (#7)<br>(Sustaining value at the end of the stage)<br>**For cognitive curiosity:**<br>- Varying level of curiosity throughout the stage (from the level of low to the level of high)<br>(Maintaining value at the end of the stage)<br>**For effort:**<br>- A high value throughout the stage (Sustaining value from the previous stage)<br>**For confidence:**<br>- A high confidence throughout the stage<br>(Preserving value from the previous stage) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Maintained/Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Preserved/Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept/Raised the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Sustained/Increased the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>L (#6)<br>N/A (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>N/A (#6)<br>H (#7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>N/A (#7) | | | | |
| Imagery | | **Attention:**<br>H (#6 - #7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>L (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.9: Case dynamic matrix 3: 'The Second Task' (snapshot 6 – snapshot 7) of case study 4 (first play)

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">How Issues in Matrix 3 Resolved:</th><th rowspan="2">Underlying Issues (as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H</td><td rowspan="6">Cognitive curiosity:<br>H<br>Effort:<br>N/A<br>Confidence:<br>H</td><td rowspan="6">For long-term relevance:<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>For attention:<br>- Presented the colourful scene - Emma's house – once again<br>For cognitive curiosity:<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>For effort:<br>- Involved an action from the participant in controlling the main character – Alex<br>For confidence:<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)</td><td rowspan="6">For long-term relevance:<br>- A high feeling of learning in the last stage<br>- A high feeling of fun in the last stage (Increasing value from the previous stage)<br>For attention:<br>- A low attention paid to the imagery used in this stage (Dropping value in the last stage compared to the previous stage)<br>For cognitive curiosity:<br>- A high level of curiosity in the last stage (Sustaining curiosity from the previous stage)<br>For effort:<br>- Not able to tell about the level of effort used in this stage<br>For confidence:<br>- A high confidence in this stage (Maintaining value from the previous stage)</td><td rowspan="6">- Resulted in unsatisfying outcome (the participant was finally not motivated to learn with the game environment)<br>- Assigned the participant to play with the adjusted version of this game</td></tr>
<tr><td>G: Provide Fun</td><td></td><td>Long-Term Relevance:<br>H</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H</td></tr>
<tr><td></td><td>Cognitive Tool</td><td>Attention:<br>AS</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>L</td></tr>
<tr><td></td><td>Feedback</td><td>Attention:<br>As</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.10: Case dynamic matrix 4: 'The Finale' (snapshot 8) of case study 4 (first play)

Table E.10 (column: How Issues in Matrix 3 Resolved) shows how the strategies explained in the previous matrix could be implemented in the game environment (considering our game prototype as an example). The ending of the story was revealed. The revelation of the ending aimed at increasing the participant's feeling of fun and preserving/raising his high level of cognitive curiosity from the previous stage. Also, the colourful scene was presented once again in order to draw the attention of the participant and to sustain/increase his high level of effort and of confidence (this scene required the action from the participant in controlling the main character and having the conversation with another character, Emma; also, presenting the familiar scene was considered to have a positive effect on his confidence level). As a result of this implementation, the values of most motivational states were reported to be high/very high in this stage except those of attention and of effort; he reported to pay low attention to the imagery used in this scene and was not able to report the level of effort used in this stage. The participant also reported to gain knowledge from doing the tasks in the game which was contradict to what he reported in the earlier stages ('N/A' value was reported when he was asked whether he could see any database knowledge in each task). Thus, it was suspected that the participant might learn from the explanation given by the cognitive tool rather than from the task itself. However, when he was asked to report his overall motivation at the end of the game, he reported to be motivated to play with the game, but not to learn from it (unsatisfying outcome). Thus, he was asked to play the adjusted version of the game which he just finished.

Another four tables of case dynamic matrices (Tables E.11, E.12, E.13 and E.14) were developed and are shown below. The tables aim at displaying how the features of the adjusted game cause changes in the values of the participant's motivational states. Since the adjusted game[5] is not different much from the original game[6], only how the differences in the adjusted version impacted on the motivational states of the participant will be explain. In the adjusted version the imagery used in 'The First Task' and 'The Second Task' stage was changed evidently. More colourful graphics were used and the process of moving the chests to the storehouses/wagons was more visible. As a result of this, there was an obvious change in the participant's feeling to learn and his feeling of fun. The participant reported to have the feeling to learn from the beginning and the feeling was reported to be preserved throughout the game. Similarly, the participant reported to have a higher feeling of fun when playing the second game compared to the first game. Furthermore, he reported to pay higher attention to the change in the game and to put a higher effort in doing the tasks. Also, he reported to feel more confident compared to when he played the first game. When the participant was asked to report his overall motivation at the end of the second game, he reported to be motivated to both learn and play which was the satisfying outcome.

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[5] The adjusted game refers to the second game. This term may also appear in the analysis of case study 5 and case study 6.

[6] The original game refers to the first game. This term may also appear in the analysis of case study 5 and case study 6.

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">Underlying Issues<br>(as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H (#1, #3)<br>N/A (#2)</td><td rowspan="6">Cognitive curiosity:<br>H (#1 - #2)<br>VH (#3)<br>Effort:<br>VH (#1)<br>H (#2 - #3)<br>Confidence:<br>VH (#1 - #2)<br>H (#3)</td><td rowspan="6">For long-term relevance:<br>- A high feeling of learning at the beginning and at the end of the stage (#1, #3)<br>- Not able to tell about the feeling of learning when doing the task in this stage (#2)<br>- A high/very high feeling of fun at the beginning and at the end of the stage (#1, #3)<br>- A low feeling of fun when doing the task in this stage (#2)<br>For attention:<br>- A high/very high value at the beginning of the stage (#1 - #2)<br>- Not able to tell about the value at the end of the stage (#3)<br>For cognitive curiosity:<br>- A high/very high value throughout the stage<br>For effort:<br>- A high/very high value throughout the stage<br>For confidence:<br>- A high/very high value throughout the stage</td><td rowspan="6">For long-term relevance:<br>- Sustained/Increases the feelings of long-term relevance by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>For attention:<br>- Raised the level of attention by using more colourful graphics in the following scenes<br>For cognitive curiosity:<br>- Preserved the level of curiosity by making use of the feature: content<br>For effort:<br>- Kept/Increased the level of effort by involving an activity which required more actions or thinking<br>For confidence:<br>- Sustained/Raised the level of confidence by making use of the feature: content</td></tr>
<tr><td>G: Provide fun</td><td></td><td>Long-Term Relevance:<br>H (#1)<br>L (#2)<br>VH (#3)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H (#1 - #3)</td></tr>
<tr><td></td><td>Cognitive Tool</td><td>Attention:<br>AS (#1 - #3)</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>H (#1)<br>VH (#2)<br>N/A (#3)</td></tr>
<tr><td></td><td>Feedback</td><td>Attention:<br>AS (#1 - #3)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.11: Case dynamic matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 4 (second play)

<table>
<tr><th colspan="2">ILE Features</th><th colspan="2">Motivational States</th><th rowspan="2">How Issues in Matrix 1 Resolved:</th><th rowspan="2">Underlying Issues (as seen by us)</th><th rowspan="2">How to Cope with</th></tr>
<tr><th>Presented Features</th><th>Absent Features</th><th>Initial States</th><th>Consecutive States</th></tr>
<tr><td>G: Support Learning</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td><td rowspan="6">Cognitive curiosity:<br>N/A (#4)<br>H (#5)<br>Effort:<br>VH (#4)<br>H (#5)<br>Confidence:<br>VH (#4)<br>H (#5)</td><td rowspan="6">For long-term relevance:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For attention:<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>For cognitive curiosity:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For effort:<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>For confidence:<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4)</td><td rowspan="6">For long-term relevance:<br>- A high/very high value throughout the stage (Sustaining value from the previous stage)<br>For attention:<br>- A high/very high value throughout the stage (Maintaining value from the previous stage)<br>For cognitive curiosity:<br>- Not able to tell about the level of curiosity at the beginning of the stage<br>- A high level of curiosity at the end of the stage (Small drop in value, but still in the positive level)<br>For effort:<br>- A high/very high level of effort used throughout the stage (Preserving value from the previous stage)<br>For confidence:<br>- A high/very high confidence throughout the stage (Sustaining value from the previous stage)</td><td rowspan="6">For long-term relevance:<br>- Sustained the feelings of long-term relevance by giving another task to do<br>For attention:<br>- Maintained/Increased the level of attention by making use of the feature: imagery<br>For cognitive curiosity:<br>- Preserved/Raised the level of curiosity by giving another task which should be slightly different from the first task<br>For effort:<br>- Kept/Increased the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>For confidence:<br>- Sustained/Raised the level of confidence by giving another task which should not be too hard compared to the first task</td></tr>
<tr><td>G: Provide Fun</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td></tr>
<tr><td>Content</td><td></td><td>Long-Term Relevance:<br>H (#4)<br>VH (#5)</td></tr>
<tr><td>Cognitive Tool (#5)</td><td>Cognitive Tool (#4)</td><td>Attention:<br>AS (#4)<br>H (#5)</td></tr>
<tr><td>Imagery</td><td></td><td>Attention:<br>VH (#4)<br>H (#5)</td></tr>
<tr><td>Feedback (#4)</td><td>Feedback (#5)</td><td>Attention:<br>H (#4)<br>AS (#5)</td></tr>
</table>

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.12: Case dynamic matrix 2: ‘The First Task’ (snapshot 4 – snapshot 5) of case study 4 (second play)

| ILE Features | | Motivational States | | How Issues in Matrix 2 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>H (#6)<br>VH (#7) | **Cognitive curiosity:**<br>L (#6)<br>H (#7)<br>**Effort:**<br>VH (#6)<br>H (#7)<br>**Confidence:**<br>VH (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- A high/very high value throughout the stage (Small drop in value, but still in the positive level; increasing value at the end of the stage)<br>**For attention:**<br>- A high attention towards the imagery and the cognitive tool throughout the stage<br>- A low attention towards feedback when it was given in the second task (#6) (Sustaining value at the end of the stage)<br>**For cognitive curiosity:**<br>- Varying level of curiosity throughout the stage (from the level of low to the level of high) (Dropping value at the beginning of the stage; increasing value at the end of the stage)<br>**For effort:**<br>- A high/very high value throughout the stage (Maintaining value from the previous stage)<br>**For confidence:**<br>- A very high confidence throughout the stage (Increasing value from the previous stage) | **For long-term relevance:**<br>- Sustained the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Maintained/Increased the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Preserved/Raised the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept/Increased the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Sustained the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>H (#6)<br>VH (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>H (#6)<br>VH (#7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>H (#7) | | | | |
| Imagery | | **Attention:**<br>H (#6 - #7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>L (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.13: Case dynamic matrix 3: ‘The Second Task’ (snapshot 6 – snapshot 7) of case study 4 (second play)

| ILE Features | | Motivational States | | How Issues in Matrix 3 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>VH | **Cognitive curiosity:**<br>H<br>**Effort:**<br>H<br>**Confidence:**<br>H | **For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene - Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For long-term relevance:**<br>- A very high feeling of learning in this stage<br>- A very high feeling of fun in this stage (Sustaining value from the previous stage)<br>**For attention:**<br>- A high attention paid to the imagery used in this stage (Maintaining value from the previous stage)<br>**For cognitive curiosity:**<br>- A high level of curiosity in this stage (Preserving curiosity from the previous stage)<br>**For effort:**<br>- A high level of effort used in this stage (Sustaining level of effort used from the previous stage)<br>**For confidence:**<br>- A high confidence in this stage (Small drop in value, but still in the positive level compared to the previous stage) | - Resulted in satisfying outcome – the participant was finally motivated to learn with the adjusted version of the game environment |
| G: Provide Fun | | **Long-Term Relevance:**<br>VH | | | | |
| Content | | **Long-Term Relevance:**<br>H | | | | |
| | Cognitive Tool | **Attention:**<br>AS | | | | |
| Imagery | | **Attention:**<br>H | | | | |
| | Feedback | **Attention:**<br>AS | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table E.14: Case dynamic matrix 4: 'The Finale' (snapshot 8) of case study 4 (second play)

## E.3.3 The Revised Causal Model

Figure E.7 shows the revised causal model of motivation of the case. The model demonstrates the ILE features, the motivational variables and the relationships among them in a form of network. The motivational variables and the ILE features are represented by nodes whereas the relationships among them are represented using links. The details about the links can be explained in the same way as in case study 1 (see section 7.3.3.3 for the explanation).

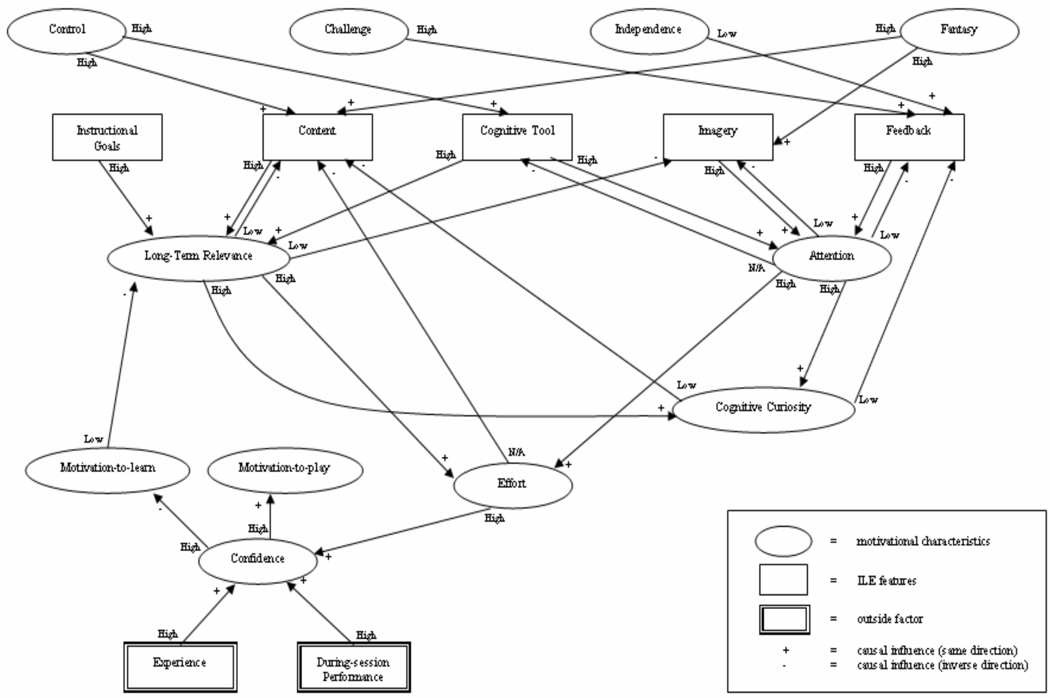


Figure E.7: The revised causal model of motivation of case study 4

The story of the model can be told as two related parts. In the trait characteristics – ILE features part the traits of the participant can be viewed as the independent variables whereas the features of the game ILE can be viewed as the dependent variables (or variables that vary according to the trait characteristics). The story of this part starts when the participant reported about his trait characteristics in a learning environment that he preferred to have control over the learning materials and to face with challenging situations; however, he did not want to be independent when learning (he preferred to get some help from the tutor when facing with difficult situations). Based on his report, MoRes assigned him to play Alex's Adventure 2.0 in which he could control some parts of the game content including the cognitive tool (the tool was considered to be a part of the content as explained in case study 1). Furthermore, the guided feedback that told him implicitly about what was supposed to be right would be given if the participant made a mistake when doing the tasks. These design attempts to make the game better matched with the high-control, high-challenge and low-independent characteristics of the participant.

In the ILE features – state characteristics part the features of the game ILE and the states of the participant can be viewed as both the independent and the dependent variables (as explained in case study 1). The story of this part begins when the participant started the interaction with the game environment.

According to the data (see Figures E.1 and E.2 for the plots of attention, Figures E.3 and E.4 for the plots of relevance and Figures E.5 and E.6 for the plots of cognitive curiosity, effort and confidence), there are fluctuations appeared in the graphs in those plots which shows that the values of the participant's motivational states can vary according to the scenes presented; some similarities and some differences do exist among these scenes; thus, some of them may contain the same features and some of them may consist of different features. To be precise, the features included in a single scene could play an important role in changes in the values of the motivational states. Hence, it was considered that the features of the game environment could exert some influences on the motivational states of the participant.

Looking at the plot of attention in the first and the second play, it was considered that the use of imagery in the game ILE could attract the attention of the participant instantly in both plays and thus, a link was drawn from the feature – imagery to attention to represent this relationship; however, there was a point in the first play where his attention was reported to be low and as a result another link was drawn backward from attention to the feature – imagery, in order to show that this feature could be adjusted in order to raise the attention of the participant. The appearance of the cognitive tool after each task in both games could also catch his attention immediately. Nevertheless, the participant made a further suggestion concerning the tool that the explanation text was quite long and it would be nice if the text could be divided into small parts or even better the audio text might be used instead of the visual text. Based on this evidence, a forward arrow was drawn from the feature – cognitive tool, to attention, to show the relationship between this feature and the attention state of the participant. Also, a backward arrow was drawn from attention to the feature – cognitive tool, in order to represent the suggestions from the participant about how the tool could be improved. Feedback given during the tasks was supposed to be able to draw the attention of the participant; however, the participant reported to pay low attention to this feature when it was given in the first game. In the second game he reported to pay high attention to the feedback given during the first task, but this did not seem to be the case in the second task. Based on this evidence, an arrow was drawn from the feature – feedback, to attention to represent the relationship in the first task of the second game. Also, another arrow was drawn backward from attention to the feature – feedback, in order to show that this feature was supposed to be adjusted when the participant reported to pay low attention to it.

As can be seen from the plot of relevance in the first and the second play (Figures E.3 and E.4), the participant's feeling of fun fluctuated strongly between the value of low and of very high throughout the game; the feeling was reported to be low in the scenes where the tasks in the game were presented. As for the feeling to learn, the participant was not able to report whether he gained any knowledge from playing the first game (mostly, 'N/A' value was reported throughout the game). However, in the second game the participant reported to have a higher feeling of fun compared to that in the first game. Also, his feeling to learn was reported to improve evidently (the graph generally falls into the high-value area) and it was considered that the changes in the second game were likely to have a strong impact on these feelings. Furthermore, the participant made a suggestion concerning the second game that it would be more interesting if the tasks in the game were more challenging. Based on this evidence, two arrows were drawn from the features: instructional goals and content, to long-term relevance to represent the effects caused by these features. Also, another two arrows were drawn backward from long-term relevance to the features: imagery and content, to show the changes in the game and to represent the suggestion from the participant. Furthermore, the use of cognitive tool was considered to have an effect on the long-term relevance state of the participant. As shown in Figure E.4 (the plot of relevance value which was measured against the features: instructional goals and content), the feelings that the game was relevant to his goal in learning were reported to be very high in snapshots 5 and 7 where the tool was presented. As a result, another arrow was drawn from the feature – cognitive tool, to long-term relevance to show the effect of the tool on this motivational state.

On the other hand, the other three motivational states: cognitive curiosity, effort and confidence, were considered to be affected by either attention or long-term relevance, or both, according to the literature described in section 4.2.3. Based on the literature and looking from the plot of cognitive curiosity, effort and confidence (Figures E.5 and E.6), the plot of attention (Figures E.1 and E.2) and the plot of relevance (Figures E.3 and E.4), the value of cognitive curiosity at each point in the plots was considered to be driven by either attention or long-term relevance, or both. That is, when the value of attention and of relevance fall into the high-value area (Attention/Relevance Value = 4 and Attention/Relevance Value = 5), the value of cognitive curiosity also falls into the same area (Cognitive curiosity Value = 4 and Cognitive curiosity Value = 5). Based on this evidence and according to the literature described in section 4.2.3, two arrows were drawn from the motivational states: attention and long-term relevance, to cognitive curiosity in order to represent the relationships among them. However, as the participant reported to have a low cognitive curiosity when the feedback was given during the tasks, a link was drawn backward from cognitive curiosity to the feature – feedback, to demonstrate that this feature could be adjusted in order to increase his cognitive curiosity. Furthermore, as explained in the earlier paragraph, the participant made a suggestion that the tasks in the second game could be adjusted to make the game more interesting. It was considered that the low cognitive curiosity partly might be because of the use of the similar tasks in both games. As a result, another link was drawn backward from cognitive curiosity to the feature – content, to represent his suggestion.

Similarly, effort is the motivational state in which its value was considered to be influenced by attention and long-term relevance. From the plot of cognitive curiosity, effort and confidence (Figures E.5 and E.6), the plot of attention (Figures E.1 and E.2) and the plot of relevance (Figures E.3 and E.4), some similarities seem to exist among these plots. The plots fall into the same positive area (the high-value area) even though the value of each of these states at some specific points in the game is not exactly the same. Thus, two links were drawn from attention and long-term relevance to effort in order to represent the relationship among them. However, there is a point in the graph of effort in the first play where the participant was not able to report the value (snapshot 8). It was considered that changing the content (such as involving an activity that requires more effort before the story ends) might be able to influence the use of effort and hence, another link was drawn backward from effort to the feature – content.

A slightly different explanation is made for confidence. From the plot of cognitive curiosity, effort and confidence (Figures E.5 and E.6), the plot of attention (Figures E.1 and E.2) and the plot of relevance (Figures E.3 and E.4), it looks like before the confidence state of the participant was affected, to some extent, he was first attracted to the game or found the relevance between his goals and the game which made him tried to progress through the game (as he reported to use a high effort in playing both games) and he was succeeded in both plays which resulted in a high level of confidence throughout the interaction with the games. Based on this piece of information, it was considered that the value of confidence was influenced by effort and hence, an arrow was drawn from effort to confidence to represent this relationship. However, the value of each of these motivational states was not exactly the same for every single point in the game. Thus, it was considered that the value of confidence might be influenced by the outside factors which are: during-session performance and experience. According to the supplemental data obtained from the participant, he reported to have experience in database modelling, but he did not mention whether he had used any database software before. He also reported to enjoy playing computer games and he has played several kinds of game such as RPGs and so on. This might be regarded as a reason for the high confidence of the participant in both plays. Also, performance during the sessions with the games was likely to play an important role in his confidence since he could perform very well in both games. Based on these reasons, two links were drawn from these two factors to confidence.

At the end of the first game the participant reported to feel motivated to play the game, but not to learn from it. Thus, he was asked to play the second game (the adjusted version of the first game). At the end of the second game the participant reported to feel motivated to both learn and play which was the satisfying outcome. It was considered that these data should be presented in the revised version of the model since it provides a better view towards the motivation of the case from both the first and the second play. This consideration leads to the augmentation of the motivation model of the case and the augmentation of the model was done based on the following rules: 1) in the context of educational game, there are two types of motivation: motivation to learn and motivation to play, and it seems not always to be the case that if a learner is motivated to play, he/she will also be motivated to learn as can be seen from the current case; hence, it was considered that motivation should be separated and thus, two nodes were added to the model: motivation to learn and motivation to play. 2) according to Keller’s (1987) ARCS model, motivation is supposed to occur after a learner feels confident; in the first play, the case reported to feel highly confident when playing the game and after the play, he reported to feel motivated to play the game, but not to feel motivated to learn from it; based on the ARCS and the result from the first play, two arrows were drawn from confidence to both types of motivation to represent the relationship between the confidence state and the motivation of the case; the arrow with a minus sign was used to represent the high confidence – low motivation-to-learn relationship whereas the arrow with a plus sign is used to represent the high confidence – high motivation-to-play relationship; in the second play, the case also reported to feel highly confident when playing the game and after the play, the case reported to feel motivated to both learn and play with the game; as a result, another arrow was drawn from motivation-to-learn to long-term relevance; this arrow shows the relationship between motivation-to-learn and long-term relevance that in order to motivate the participant to learn from the game, the value of long-term relevance could be increased by either adjusting the tasks in the game (content) or improving the representation of the knowledge embedded in the tasks (imagery) as mentioned earlier in this section.

## E.4 Summary of Case Study 4

This case was considered to be a special ‘non-motivated’ case since the participant was not motivated to learn after the first game. As a result, he was asked to play the second game which is the adjusted version of the first game and this version succeeded in motivating him.

The participant was asked to provide the trait characteristics in a learning environment and based on his report, MoRes assigned him to play Alex’s Adventure 2.0 which was considered to be the version that suits with his traits. The trait characteristics of the case were shown in Table E.1. Also, he was asked to report his motivational states during interactions with both games and his overall motivational states after finishing playing each game. The data regarding his motivational states during both interactions was presented using the event listing tables (Tables E.2 and E.3) and the plots of motivational states (Figure E.1 – Figure E.6). The effects matrix of ILE features (Table E.4) was also used to describe the effects of the game features on the motivational states of the case in both plays. The causal mechanisms between the trait characteristics of the case, the features of the game and the state characteristics of the case in both plays were revealed using the explanatory effects matrices (Tables E.5 and E.6) and eight case dynamic matrices (Table E.7 – Table E.14). The revised causal model of motivation of the case was also created to present these causal mechanisms in a coherent picture (Figure E.7).

Some major findings can be drawn from the study of this case as follows:

- In the context of educational game motivation can be separated into two types: motivation-to-learn and motivation-to-play.
- In the context of educational game if one is motivated to play, it is not always the case that he/she will also be motivated to learn.
- To increase the motivation in learning, the feelings of long-term relevance should be raised and one viable method was to adjust the representations of the knowledge in the game ILE (imagery).
- Adjusting the feature: content, was likely to be able to raise the feelings of long-term relevance (e.g. changing the way in which the knowledge was presented).
- To raise the attention level, the features: imagery, cognitive tool and feedback, could be adjusted (e.g. making an improvement to the graphics used in the game).

- To increase the cognitive curiosity, the features: feedback and content, could be adjusted (e.g. changing the feedback style given during the tasks).
- To increase the level of effort used in the game ILE, the feature: content, could be adjusted (e.g. including a more complicated activity/task).
- Similar to the other cases, confidence was the motivational state in which its value was considered to be influenced by the outside factors: experience and during-session performance; however, it was not obvious whether these factors could also have an influence on the other motivational states.

# Appendix F

# The Analysis of Case Study 5

This appendix presents the analysis of case study 5 (case E01). The analysis was done in a similar fashion compared to the other cases (case study 1 and case study 6 (chapter 7), case study 2 (Appendix C) and case study 3 (Appendix D), case study 4 (Appendix E)).

F.1 Background of Case Study 5

F.2 Representations for Describing the Motivation of Case Study 5

- F.2.1 Event Listing of Motivational State
- F.2.2 Plot of Motivational State
- F.2.3 Effects Matrix of ILE Features

F.3 Representations for Explaining the Motivation of Case Study 5

- F.3.1 Explanatory Effects Matrix
- F.3.2 Case Dynamics Matrix
- F.3.3 The Revised Causal Model

F.4 Summary of Case Study 5

# F.1 Background of Case Study 5

The participant is a male gender whose age is between 20 -25 years old. He is an international student and he is doing his master degree in computing science. The participant reported having some knowledge in the area of database modelling (from reading books), but has never been on any database modelling course before. However, he reported having experience in creating databases, but did not mention the name of the database software that he used. As for his experience in computer games, he reported playing some small games before. At the start of the session with our computer program – MoRes, the participant was asked to provide the data about some of his trait characteristics in a learning environment. These characteristics are shown in Table F.1.

Based on his trait characteristics, MoRes assigned him to play Alex's Adventure 2.0[1].

| **Control** | **Challenge** | **Independence** | **Fantasy** |
|---|---|---|---|
| High | High | High | High |

Table F.1: Trait characteristics of case study 5

However, after the participant finished playing the game he reported that he was not motivated to learn from it and thus, he was asked to play the adjusted version of Alex's Adventure 2.0 (Alex's Adventure 6.0). The motivational data of the participant from the interaction with the two games are presented alongside each other in order to show changes in the values of the motivational states when playing the first and the second game, accordingly. As already mentioned in the analysis of case study 6 (chapter 7), the term 'first play' and 'second play' may appear in the following sections which refer to the time when the participant played the first game (Alex's Adventure 2.0) and the second game (the adjusted version of Alex's Adventure 2.0), respectively.

[1] The specifications of Alex's Adventure 2.0 were described in chapter 5 (section 5.3.1.4).

# F.2 Representations for Describing the Motivation of Case Study 5

## F.2.1 Event Listing of Motivational State

Table F.2 is a table of event listing which was created based on the data reported through the use of retrospective self-report. The table aims at displaying the values of the motivational states of the case when playing the first game.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Attention** | **Imagery** | VH | H | L | H | H | H | L | N/A |
| | **Feedback** | AS | AS | AS | H | AS | N/A | AS | AS |
| | **Cognitive Tool** | AS | AS | AS | AS | VL | AS | L | AS |
| **Relevance** | **Content** | VH | N/A | VL | VL | L | L | L | VH |
| | **Goal: Support Learning** | VH | VL | VL | VL | L | L | L | VL |
| | **Goal: Provide Fun** | VH | L | H | H | L | VL | L | H |
| **Cognitive Curiosity** | | H | N/A | VH | H | VL | N/A | L | L |
| **Effort** | | H | L | VH | H | L | H | VL | N/A |
| **Confidence** | | N/A | VH | N/A | H | L | VH | N/A | VH |

Legend:

| | | | |
|---|---|---|---|
| Legend: | VL | = | Very Low |
| | L | = | Low |
| | N/A | = | Not Applicable |
| | H | = | High |
| | VH | = | Very High |
| | AS | = | Absent feature from the scene |

Table F.2: Event listing of motivational state of case study 5 (first play)

According to the data shown in the table and our observational notes, the participant seemed to feel attentive to the beginning scenes as he stared at the scenes all the time and moved his top body closer to the screen when reading the introduction to all characters in the 'Invitation' scene. He also looked curious to start playing the game as he clicked the button 'Play Game' immediately. When the 'In the Forest' scene was presented, the participant seemed to pay attention to the conversation between the characters appeared in the scene. Furthermore, when he was asked to find all hidden mushrooms in the forest to progress through the next scene, he looked curious and made an effort in completing this activity (looked over the screen **(:G1)**). After he finished collecting the mushrooms and saw the scene was changing, he seemed to feel satisfied **(:F1)**. When the next scene was presented (the 'Meet Dr de Ville' scene), the participant reported not to feel attracted to the appearance of the other two characters – Dr de Ville and Mary, but he seemed to pay attention to the conversation among the characters appeared in this scene (seemed to think along **(:G2)**) as he reported to have a very high cognitive curiosity in this scene. In the following scene – the 'First Task' scene, the participant was likely to be attracted by objects and dialog boxes describing the scenario of the first task and how to do it **(:G1)**. Also, he seemed to have a high concentration when doing the task as he reported to have a high cognitive curiosity in this scene; however, it looked like he did not understand how to do the task and seemed to play the game by guessing (did not check the information kept in the chests before choosing which one he was going to move **(:G3)**). He made a few mistake when doing the task (he could make only 2 correct choices) and looked unsure after the task was finished. In the ‘Meet Mushyman #1’ scene the participant was likely to be attracted by the appearance of the character, Mushyman and seemed to concentrate on its explanation about the knowledge embedded in the task (stared at the screen all the time **(:G4)**); however, based on his report, he did not feel fun at this point in the game nor gain any knowledge from the explicit explanation; also, his cognitive curiosity was reported to be very low. In the ‘Second Task’ scene the participant reported to pay high attention to the objects appeared in the scene. He also seemed to highly concentrate when doing the task and looked like he knew how to do the task (checked the information kept in the chests before choosing which one he was going to move **(:G5)** and some chests was checked several times **(:G6)**). He finished the second task without making any mistake and looked satisfied **(:F1)**. In the following scene (the ‘Meet Mushyman #2’ scene) the participant was presented with the explanation about the second task and according to his report, he paid low attention to this scene and did not feel fun nor gain any knowledge from the explanation. Also, he reported to have a low cognitive curiosity and to use a very low effort at this point in the game. In the last scene where the ending of the story was revealed, the participant reported that the story was enjoyable; however, he was not able to report his attention paid to this scene and the level of effort used at this point in the game.

| | | Snapshots | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Attention** | **Imagery** | L | L | L | N/A | L | N/A | L | N/A |
| | **Feedback** | AS | AS | AS | N/A | AS | N/A | AS | AS |
| | **Cognitive Tool** | AS | AS | AS | AS | VL | AS | VL | AS |
| **Relevance** | **Content** | L | L | L | VL | N/A | L | N/A | H |
| | **Goal: Support Learning** | L | VL | L | VL | L | L | L | VL |
| | **Goal: Provide Fun** | N/A | VL | N/A | VL | L | VL | L | H |
| **Cognitive Curiosity** | | N/A | N/A | H | N/A | VL | L | VL | N/A |
| **Effort** | | L | N/A | H | N/A | L | N/A | L | N/A |
| **Confidence** | | N/A | VH | H | VH | VL | N/A | N/A | H |

| | | | |
|---|---|---|---|
| Legend: | VL | = | Very Low |
| | L | = | Low |
| | N/A | = | Not Applicable |
| | H | = | High |
| | VH | = | Very High |
| | AS | = | Absent feature from the scene |

Table F.3: Event listing of motivational state of case study 5 (second play)

Similarly, Table F.3 displays the values of the motivational states of the case when playing the second game. The participant's attention was reported to drop to a low level in the second play as well as his feeling of fun. His feeling to learn was not different from the first play (the feeling was reported to be at a low level throughout the second game). Furthermore, he reported to feel more curious and put more effort when playing the first game. Also, the participant reported to have a higher level of confidence when playing in the non-serious part[2] of the second game, but he reported to have a lower level of confidence when playing in the serious part[3] of the game.

### F.2.2 Plot of Motivational State

Six plots of motivational state were developed. The first two plots (Figures F.1 and F.2) are the plots of attention in the first and the second play. The next two plots (Figures F.3 and F.4) are the plots of relevance in the first and the second play and the last two plots (Figures F.5 and F.6) are the plots of three motivational states: cognitive curiosity, effort and confidence, in the first and the second play.

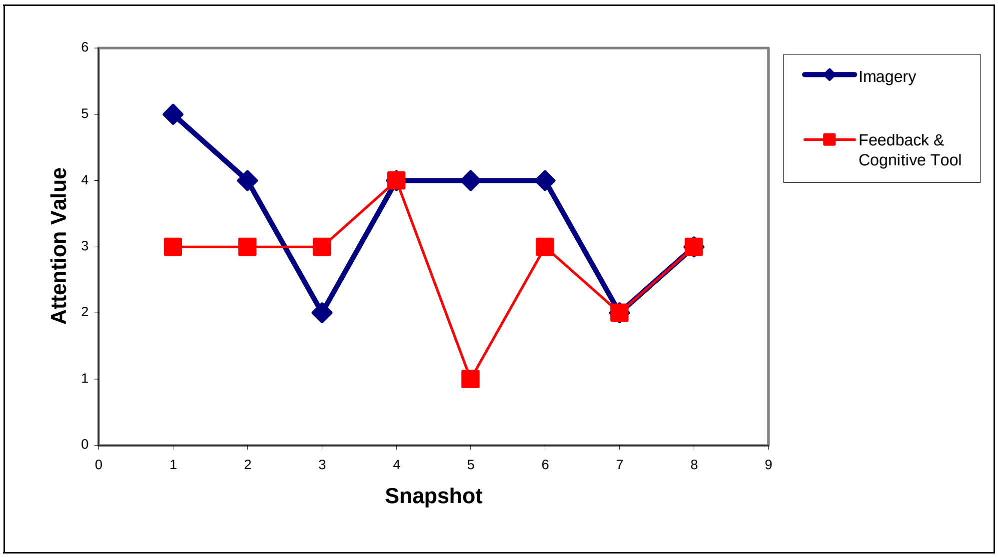


Figure F.1: Attention value towards three features of the game during the first play

[2] The non-serious part of the game refers to the part that is not involved with the ERM knowledge (snapshot 1, snapshot 2, snapshot 3 and snapshot 8).

[3] The serious part of the game refers to the part that involves with the ERM knowledge (snapshot 4 – snapshot 7).

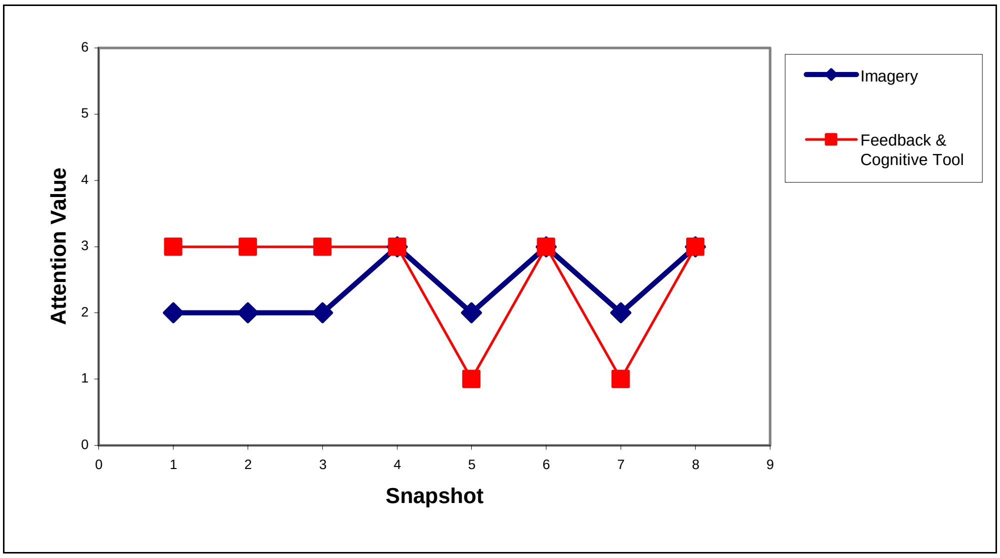


Figure F.2: Attention value towards three features of the game during the second play

Figures F.1 and F.2 show the values of the participant's attention towards three features of the game (imagery, feedback and cognitive tool) in the first and the second play, respectively. According to the figures, the participant was attracted to the imagery used in the first game as the attention value was reported to be high/very high (Attention Value = 4 and Attention Value = 5) in general; however, there were two points where he reported to pay low attention (snapshots 3 and 7) which might be because a less colourful scene was used in snapshot 3 and a scene with the similar theme (compared to the earlier scene) was used in snapshot 7. Also, there was a point in which the participant was not able to report his attention (snapshot 8) which might be because the repetitive scene was used. On the contrary, the participant reported to pay lower attention when playing the second game as can be seen from Figure F.2 that the graph fluctuates in the low-value area. Thus, it was considered that the changes made to the imagery in the second game did not have strong effects on his attention. As for the feature – feedback, the participant reported to pay high attention when it was given during the first task of the first game; however, a low level of attention was reported when this feature was given during the second task of the game. Similarly, in the second game, the participant reported to pay low attention to the feedback given during both tasks of the second game. As for the feature – cognitive tool, the participant reported to pay low attention whenever this feature was presented in both games.

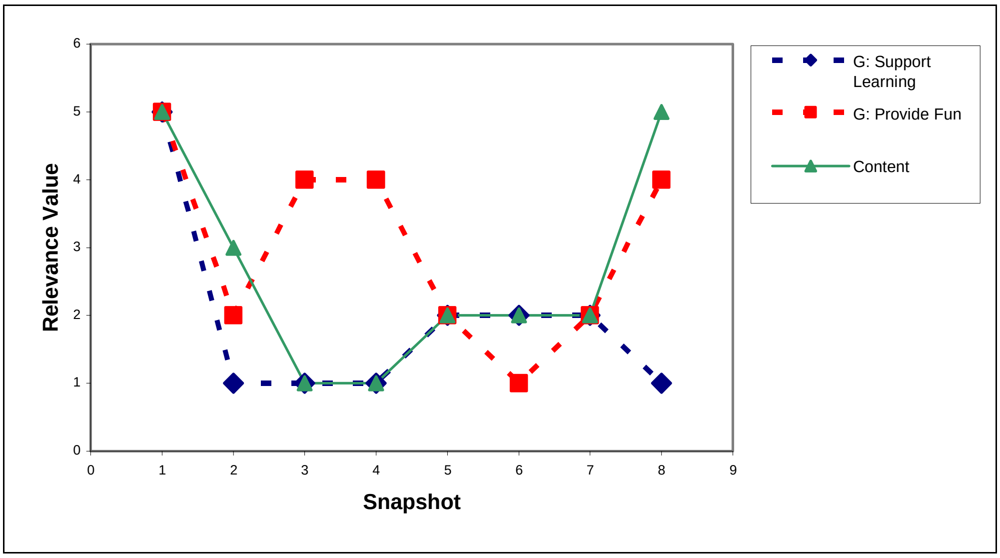


Figure F.3: Relevance value towards two features of the game during the first play

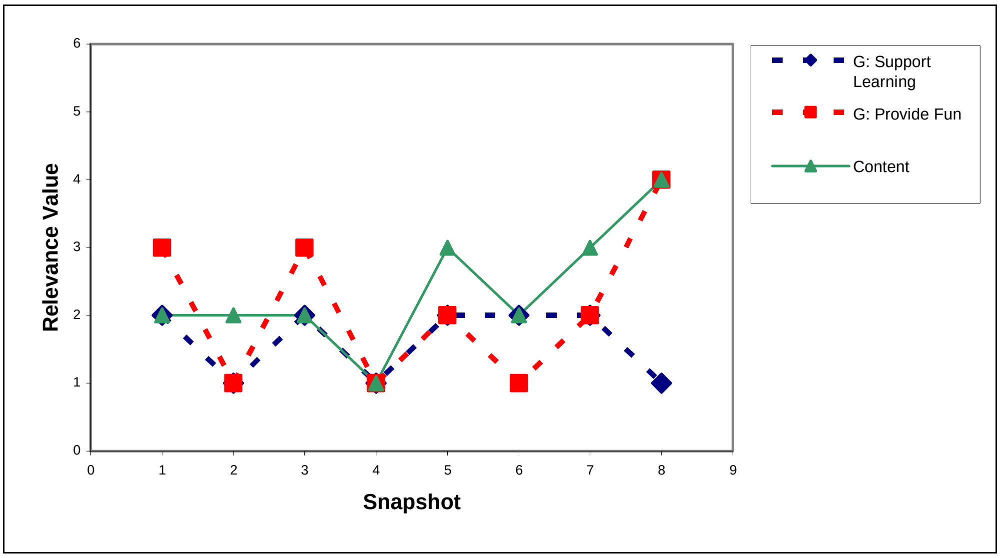


Figure F.4: Relevance value towards two features of the game during the second play

Figures F.3 and F.4 show the feelings of relevance of the participant towards two features of the game: instructional goals (support learning and provide fun) and content in the first and the second play, respectively. According to the figures, the participant seemed to have the goal to learn from playing the game as he reported to feel interested in the database knowledge embedded in the first game at the start; this shows his high feelings that the game, to some extent, was related to his needs. However, his feeling to learn was reported to drop to a low level afterwards and remained at this level until the end of the first game. As for the feeling of fun, it seems that the participant also had an intention to have fun with the game at the beginning; however, his feeling of fun was reported to vary between the level of low and of high depend on the scenes presented in the game. In the second game the participant still reported to have a low feeling to learn and his feeling of fun mostly dropped to a low level throughout the game.

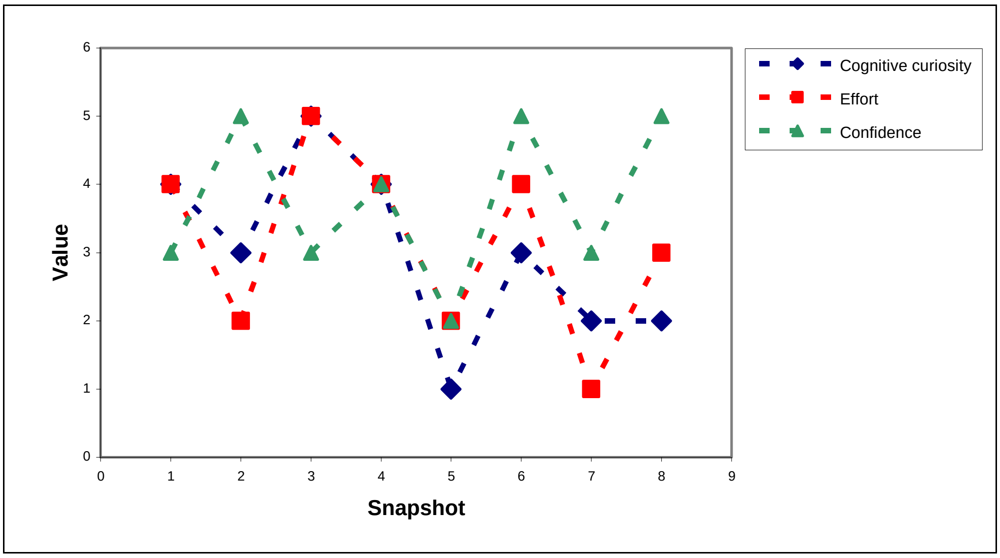


Figure F.5: The value of cognitive curiosity, of effort and of confidence during the first play

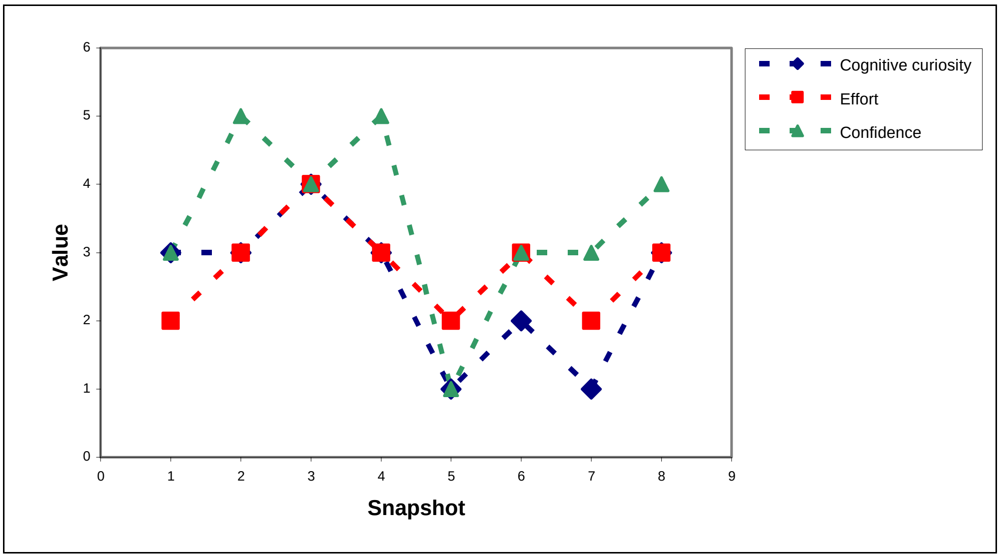


Figure F.6: The value of cognitive curiosity, of effort and of confidence during the second play

Figures F.5 and F.6 show the values of the following motivational states during the game interaction: cognitive curiosity, effort and confidence, in the first and the second play, respectively. According to the figures, the participant reported to have a higher level of cognitive curiosity in the first half of the first game compared to that in the second half of the game. In the second game the level of his cognitive curiosity was likely to be lower than that in the first game. As for the effort state, the participant reported to use a higher level of effort in playing the first game (compared to the second game) as there are four points in the graph (Figure F.5) where he reported to use a high/very high effort (snapshots 1, 3, 4 and 6). On the contrary, a lower level of effort was reported to be used when he played the second game as can be seen from the graph (Figure F.6) that there is only one point where the participant reported to use a high effort (snapshot 3). As for the confidence state, the participant reported to have similar level of confidence when playing both games as there are four points in the graph (Figure F.5) where he reported to feel highly confident (snapshots 2, 4, 6 and 8). These points were the points where the participant was successful at doing the tasks in the game. Similarly, there are four points in the graph (Figure F.6) where he reported to have a high/very high level of confidence (snapshots 2, 3, 4 and 8). Again, some of these points were the points where the participant was successful at doing the tasks in the second game.

### F.2.3 Effects Matrix of ILE Features

Table F.4 is a table of effects matrix and it was created to describe the effects of game features on the motivational states of participant in the first and the second play; the table displays five features that make up the game ILE and three kinds of effects considered to be caused by these features. Similar to case study 6, a single table was built. The description of the table (below) was created based on existing literature as explained in chapter 4 (section 4.2.3) and evidences (data from post-questionnaire, self-report, observational notes and semi-structured interview).

According to the table, the imagery used in the first game could attract the attention of the participant straight away. It also made him felt curious about the following scenes. However, when the participant played the second game (the adjusted version of the first game), he reported to pay low attention to the scenes as most scenes are similar to those in the first game. Nevertheless, he reported to feel curious about how the second game would be different from the first game.

In the first game when the participant was given the feedback during the first task, he reported to pay high attention and felt curious about what feedback would be given. However, he was not able to tell his attention paid to this feature given during the second task of the first game and also, during both tasks of the second game. In addition, his curiosity towards this feature was reported to be low.

As for the feature – cognitive tool, the participant reported to pay high attention to its appearance when it appeared after the first task in the first game was finished; however, he did not feel curious about the explanation given by the tool. When the tool appeared again after the second task, the participant reported not to pay attention nor feel curious about its explanation. Similarly, the participant reported to pay very low attention to the appearance of the tool after each task in the second game was finished. Also, he reported to have a very low level of curiosity about its explanations. As for the content of the game, the participant reported to feel a high coherency in the story of the game. He also felt curious about what the tasks in both games would be like and how the story would end in both games. However, he reported not to be able to see the relevance between the tasks in the first game and the ERM knowledge whereas he reported not to be able to tell these feelings in the second game. Also, he reported not to feel curious in gaining knowledge from the tasks and the explanations about the tasks in both games.

| **ILE Features** | **Direct Effects** | | **Meta Effects** | | **Side Effects** |
|---|---|---|---|---|---|
| | + | - | + | - | + |
| Imagery | Scenes in the first game attracted the attention of the participant in general | A low attention paid in the scenes presented in the second game | Curious to see the following scenes; wanted to know the differences between the first and the second game | | |
| Feedback | A high attention paid to the feedback given during the first task of the first game | Not able to tell about the attention towards the feedback given during the second task of the first game and also, during both tasks of the second game | A high curiosity about what feedback would be given during the first task of the first game | Not able to tell about the curiosity towards the feedback given during the second task of the first game and during the first task of the second game; A low curiosity during the second task of the second game | |
| Cognitive Tool | A high attention paid to the tool when it appeared after the first task in the first game was finished | A low attention paid to the explanations given by the tool in both games | | A low curiosity towards the explanations given by the tool in both games | |
| Content | Felt a high coherency in the storyline of the game | Seemed not to be able to clearly see the relevance between the tasks and the database knowledge in the first game; Not able to tell about this perception in the second game | Curious about how the story would end in both games; Curious about what the tasks in both games would be like | Seemed not to feel curious in gaining knowledge from the tasks and the explanations presented in both games | |
| Instructional goals | Seemed to have an intention in having fun at the start of the first game and the game satisfied him; Not able to tell about these feelings at the start of the second game, but he reported to feel fun after finishing playing the second game | Seemed to be interested in learning at the start of the first game, but at the end of the game he reported not to be motivated to learn from it; Not likely to have a feeling of learning when playing the second game | | | |

Sources: Post-questionnaire, retrospective self-report, observational notes and semi-structured interview

Table F.4: Effects matrix of ILE features of case study 5

After the participant finished playing the first game, he reported that he enjoyed playing the game; however, he did not gain any ERM knowledge from the game. Also, he made a comment that the tasks in the first game should combine ERM knowledge into them. Based on his report, it seems that the participant did not perceive that the database knowledge was already embedded in the tasks. After the participant finished playing the second game, he reported that the game was similar to the previous game except that some graphics were changed. He also reported further that the game was easy and it was not interesting to play the game twice. In addition, he felt more exciting when playing the first game compared to the second game. Still, it seems that he did not perceive any database knowledge embedded in the tasks as he kept making a comment that the tasks in the second game should involve the use of ERM knowledge in solving the problems.

## F.3 Representations for Explaining the Motivation of Case Study 5

### F.3.1 Explanatory Effects Matrix

Tables F.5 and F.6 were created aiming to display the overall picture of the relationships among trait characteristics, ILE features and state characteristic in the first and the second play, respectively. Similar to the other case studies, the explanation of the table was created based on existing literature (section 4.2.3) and evidences (data from post-questionnaire and self-report).

According to the tables, the participant reported about his trait characteristics in a learning environment that he preferred to have a high control and he enjoyed challenging situations; he also preferred to be independent when learning. As a result of his report, MoRes assigned him to play Alex's Adventure 2.0. In this version he could have control over the features: content and cognitive tool. That is, he could select which storehouse/wagon he preferred to start working with when doing the tasks in the game (content) and he could choose whether to receive the explanation from Mushyman after finishing with each task (cognitive tool). Furthermore, if he made a mistake when performing the tasks, he would receive the guided feedback informing implicitly about what was supposed to be right. However, the participant reported not to feel motivated to learn at the end of the game, and thus, he was asked to play the adjusted version of Alex's Adventure 2.0 (Alex's Adventure 6.0). This version of the game is similar to the original version except that some changes were made to the imagery (see section 5.3.1.4 for more details on the changes).

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state) | | Longer-Run Consequences (overall-state perspective) | |
|---|---|---|---|---|---|---|
| | | | **Direct Effects** | **Meta Effects** | **Initial States** | **Consecutive States** |
| | Instructional goal:<br>Support Learning | | **Long-Term Relevance:** Seemed to be interested in learning at the start of the game, but seemed not to gain any database knowledge from playing the game | **Cognitive curiosity:** Generally, a high curiosity in the first half of the game; a lower level of curiosity when the repetitive scenes were used and the similar task was presented in the second half of the game<br>**Effort:** Varying level of effort used in different scenes of the game<br>**Confidence:** Varying confidence level throughout the game; a low confidence was reported when the explanation was given in the first task | **Long-Term Relevance:** L | **Cognitive curiosity:** H<br>**Effort:** VL<br>**Confidence:** H |
| | Instructional goal:<br>Provide Fun | | **Long-Term Relevance:** Seemed to have an intention in having fun at the start of the game and the game was likely to satisfy him | | **Long-Term Relevance:** H | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Long-Term Relevance:** Seemed not to be able to clearly see the relevance between the tasks and the database knowledge in the game | | **Long-Term Relevance:** H | |
| | Cognitive Tool | Can choose not to receive the explanations from Mushyman | **Attention:** Caught the attention of the participant by the immediate appearance of the tool when it appeared after the first task, but not attracted to its explanation and seemed to pay less attention when it appeared again after the second task | | **Attention:** L | **Cognitive curiosity:** L/H/H<br>**Effort:** L/VH/H<br>**Confidence:** L/VH/H |
| Challenge | Feedback | Guided feedback | **Attention:** Paid high attention to the feedback given during the first task, but not able to tell about his attention when the feedback was given in the second task | | **Attention:** H | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** Attracted the participant's attention in general; Less attracted to the repetitive scene and the scene with the less colourful graphics | | **Attention:** H | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Felt a high coherency in the storyline of the game, but did not seem to clearly see that the knowledge was already embedded in the game | | **Long-Term Relevance:** H | **Cognitive curiosity:** H<br>**Effort:** VL<br>**Confidence:** H |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.5: Explanatory effects matrix of case study 5 (first play)

| Trait | ILE Features | Game Characteristics | Short-Run Effects (process perspective on state) | | Longer-Run Consequences (overall-state perspective) | |
|---|---|---|---|---|---|---|
| | | | Direct Effects | Meta Effects | Initial States | Consecutive States |
| | Instructional goal: Support Learning | | **Long-Term Relevance:** Not likely to have a feeling of learning when playing the second game | **Cognitive curiosity:** Curious about the differences between the first and the second game, but after playing the game for a while and perceived some small changes, the level of cognitive curiosity was decreased **Effort:** Varying level of effort used in different scenes of the game, but a lower level of effort (compared to that used in the first game) was reported in general **Confidence:** Varying level of confidence throughout the game; a very low confidence was reported when the participant was given the explanation about the first task | **Long-Term Relevance:** VL | **Cognitive curiosity:** H **Effort:** L **Confidence:** VH |
| | Instructional goal: Provide Fun | | **Long-Term Relevance:** Not able to tell about this feeling at the start of the second game, but he reported to feel fun after finishing playing the second game | | **Long-Term Relevance:** VH | |
| Control | Content | Can choose the storehouse/the wagon to start working with | **Long-Term Relevance:** Not able to report about the perception of the relevance between the tasks and the database knowledge in the game | | **Long-Term Relevance:** H | |
| | Cognitive Tool | Can choose not to receive the explanations from Mushyman | **Attention:** A low attention paid to the tool and its explanations about the tasks in the game | | **Attention:** L | **Cognitive curiosity:** VL/H/H **Effort:** L/VH/H **Confidence:** L/VH/VH |
| Challenge | Feedback | Guided feedback | **Attention:** Not able to tell about his attention towards the feedback given during both tasks in the game | | **Attention:** H | |
| Independence | Feedback | Can choose to/not to receive the feedback from Mary/James | | | | |
| Fantasy | Imagery | Visual graphics, audio graphics (background music & sound effects) | **Attention:** A low attention paid in the scenes presented in this second game | | **Attention:** H | |
| | Content | Coherency of the storyline, embedded database knowledge in the tasks | **Long-Term Relevance:** Felt a high coherency in the storyline of the game, but was not able to report about the perception of the relevance between the tasks and the database knowledge in the game | | **Long-Term Relevance:** H | **Cognitive curiosity:** H **Effort:** L **Confidence:** VH |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.6: Explanatory effects matrix of case study 5 (second play)

As shown in the tables, two instructional goals (support learning and provide fun) were seen as having effects on the long-term relevance state of the participant directly. Based on the data (see Figure F.3), the participant seemed to have the goal in learning at the start of the first game; however, it was considered that he might not gain any ERM knowledge from playing the game as the graph of his feelings that the game was relevant to his goal in learning (the plot of relevance which was measured against the instructional goal: support learning) falls into the low level mostly. As for his feeling of fun, it was considered (based on his report) that the participant had an intention to have fun when playing the game from the beginning and the first game was likely to satisfy him. However, what happened in the first play did not seem to be the case for the second play. The participant seemed not to have an intention to learn from the game from the start and his feeling to learn was reported to be at a low level throughout the game. As for his feeling of fun, the participant reported to feel less fun when playing the second game compared to when he played the first game. At the end of the second game he reported about his overall motivation towards this version of the game that he was happy to play the game, but he was not happy to learn from it.

Content (the story and the knowledge embedded in the game) is the feature that was also considered to have a direct effect on the long-term relevance. The participant reported to feel a high coherency in the storyline of both games and it was the storyline that kept him playing the games. However, in the first game the participant reported not to be able to see the relevance between the tasks and the ERM knowledge clearly. Similarly, he was not able to report whether he saw this relevance in the second game. Also, when looking at the plot of relevance which was measured against content (see also Figures F.3 and F.4), the graphs generally fall into the low-value area in both plays. According to his report and based on the graph, it was considered that the content of both games could satisfy his feeling of fun, but it did not succeed in fulfilling his feeling to learn from it.

On the other hand, cognitive tool, feedback and imagery are the features which were considered to have a direct effect on the participant's attention. According to the plots of attention which was measured against these features in the first play and the second play (see Figures F.1 and F.2), the participant was attracted to the imagery used in the first game in general; however, when the less colourful scene and the repetitive scene were used, he reported to pay a lower level of attention. In the second game the participant reported to pay lower attention to the imagery since in his view only some small changes were made to the game. The use of cognitive tool to explain the knowledge was reported to be able to draw his attention when it appeared after the first task of the first game was finished; however, the participant's attention was reported to drop when the tool appeared again after the second task. In the second game the participant reported to pay very low attention whenever the tool appeared. As for the feature – feedback, the participant reported to pay high attention when it was given during the first task of the first game, but he was not able to report his attention when this feature was given during the second task of the first game and also, during both tasks of the second game.

Apart from causing the direct effect as explained earlier, the features were also considered to cause the meta effects. Three motivational states were considered to be the meta effects caused by the features of the game ILE: cognitive curiosity, effort and confidence. According to the data (see Figures F.5 and F.6), the participant reported to have a high cognitive curiosity in the first half of the first game where new scenes/new activity/new task were introduced, but his curiosity was reported to drop when the repetitive scenes were used and the similar task was presented in the second half of the first game. However, when the participant started playing the second game, he reported to feel curious about the differences between this version of the game and the previous version of the game. But after he played the game for a while and perceived only some small changes, the level of his cognitive curiosity was reported to decrease. Based on his report, it was considered that before the cognitive curiosity state of the participant was affected, to some extent, he was first attracted to the game or found the game could satisfy his intention to have fun. In addition, it was noticed that the values of cognitive curiosity, to some extent, were influenced by attention and long-term relevance. For example, in the fourth snapshot of Figure F.5 (the ‘First Task’ scene in the first game) the value of cognitive curiosity is the same as the value of attention (which was measured against the features: imagery and feedback) and as the value of relevance (which was measured against the instructional goal: provide fun).

As for the effort state, varying level of effort was reported when playing both games. In the first game a high/very high level of effort was reported to be used in the scenes that required thinking or involved with challenging situations. For example, in the ‘Meet Dr de Ville’ scene in which the tasks in the game were mentioned, the participant reported to use a very high effort in figuring out what the tasks would be like. Another example is when the first task of the game was presented to him in the ‘First Task’ scene; the participant reported to use a high effort in solving the problems in the task. However, a low/very low effort was reported to be used in the scene which, according to the participant’s view, contained less challenging activity (the ‘In the Forest’ scene) or less attractive activity (the ‘Meet Mushyman #1’ scene and the ‘Meet Mushyman #2’ scene). In the second game the participant reported to use a lower level of effort compared to when playing the first game. Based on his report, it was considered that for the participant to make an effort in playing the game, he tended to feel attracted to the game first or found that the game was relevant to his goal in having fun. As a result, effort was also regarded as the motivational state that seemed to be affected after attention and long-term relevance.

The similar explanation can be made for the confidence state of the participant. In the first game the participant reported to have varying levels of confidence throughout the game. He reported to have a high/very high confidence in the scene that involved an activity in which he was capable of doing it such as the ‘In the Forest’ scene, the ‘First Task’ scene and the ‘Second Task’ scene. However, he reported to have a low confidence when he was given the explicit explanation about the ERM knowledge embedded in the game for the first time (the ‘Meet Mushyman #1’ scene) and he was not able to report his confidence when it was given for the second time. He was also not able to report his confidence in the scene which did not contain any activity such as the ‘Opening & Invitation’ scene. Similarly, the confidence of the participant was reported to vary between the level of very low and of very high when playing the second game. It was considered that before the confidence state of the participant was affected, to some extent, he was first attracted to some elements in the game or found the relevance between his goals and the game which made him tried to progress through the game; when he succeeded in doing so, he gained more confidence. Based on this, it was considered that confidence was the motivational state that was likely to be affected after attention and long-term relevance.

### F.3.2 Case Dynamics Matrix

Tables F.7, F.8, F.9 and F.10 were developed aiming to display how the features of the first game cause changes in the values of the participant’s motivational states.

| **ILE Features** | | **Motivational States** | | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | |
| G: Support Learning | | **Long-Term Relevance:**<br>VH (#1)<br>VL (#2 - #3) | **Cognitive curiosity:**<br>H (#1)<br>N/A (#2)<br>VH (#3)<br>**Effort:**<br>H (#1)<br>L (#2)<br>VH (#3)<br>**Confidence:**<br>N/A (#1, #3)<br>VH (#2) | **For long-term relevance:**<br>- A very high value at the start of the stage (#1)<br>- A very low/low value when the participant was asked to complete a task (#2)<br>- A very low feeling of learning at the end of the stage (#3)<br>- A high feeling of fun at the end of the stage (#3)<br>**For attention:**<br>- A high/very high value earlier in the stage (#1 - #2)<br>- A low value at the end of the stage (#3)<br>**For cognitive curiosity:**<br>- A high value at the beginning of the stage (#1)<br>- Not able to tell about the value at the middle of the stage (#2)<br>-A very high value at the end of the stage (#3)<br>**For effort:**<br>- A high value at the start of the stage (#1)<br>- A low value at the middle of the stage (#2)<br>- A very high value at the end of the stage (#3)<br>**For confidence:**<br>- Not able to tell about the value at the start (#1) and at the end (#3) of the stage<br>- A very high value at the middle of the stage | **For long-term relevance:**<br>- Increased the feeling of learning and sustained/raised the feeling of fun by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>**For attention:**<br>- Raised the level of attention by using more colourful graphics in the following scenes<br>**For cognitive curiosity:**<br>- Maintained the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Kept the level of effort by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide fun | | **Long-Term Relevance:**<br>VH (#1)<br>L (#2)<br>H (#3) | | | |
| Content | | **Long-Term Relevance:**<br>VH (#1)<br>N/A (#2)<br>VL (#3) | | | |
| | Cognitive Tool | **Attention:**<br>AS (#1 - #3) | | | |
| Imagery | | **Attention:**<br>VH (#1)<br>H (#2)<br>L (#3) | | | |
| | Feedback | **Attention:**<br>AS (#1 - #3) | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.7: Case dynamic matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 5 (first play)

As can be seen from Table F.7 (column: Underlying Issues (as seen by us)), the participant reported to pay high attention to the imagery used in the early scenes of the first stage (#1 and #2 in 'The Prelude'); however, he reported to pay low attention in the last scene of the stage. Also, the participant reported to feel interested in learning ERM at the beginning of the stage, but, the feeling was likely to slip away as he progressed through the rest of the stage (the participant reported not to have any suspicion towards the tasks, which was mentioned at the end of the stage, that it might be relevant to learning ERM). Furthermore, he seemed to have a high intention to have fun at the beginning and at the end of the stage, but the feeling of fun was reported to drop when he was asked to finish an activity at the middle of the stage. As for cognitive curiosity and effort, the participant reported to have a high level of curiosity at the beginning and at the end of the stage, but he was not able to report his curiosity when he was doing the activity in this stage. A high effort was reported to be used at the beginning and at the end of the stage; however, a low effort was reported when doing the activity. As for confidence, the participant reported to feel highly confident when he was doing the activity in this stage, but he was not able to report his confidence level at the other points of the stage. According to his report, the strategies were specified in order to deal with these issues as can be seen from the column: How to Cope with. It was considered that the game could consider raising the level of attention by using more colourful graphics in the following scenes. His high feeling of fun could be sustained/increased by including more fun elements (such as surprised events or interactive activities) in the consecutive scenes. The feeling to learn of the participant should be increased and to achieve this, the knowledge embedded in the game was considered to be presented in the subsequent scenes. The presentation of the knowledge was also supposed to be able to preserve the very high level of cognitive curiosity and of effort through the next stage. In addition, the game could consider raising the level of confidence of the participant in the next stage.

| ILE Features | | Motivational States | | How Issues in Matrix 1 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>VL (#4)<br>L (#5) | **Cognitive curiosity:**<br>H (#4)<br>VL (#5)<br>**Effort:**<br>H (#4)<br>L (#5)<br>**Confidence:**<br>H (#4)<br>L (#5) | **For long-term relevance:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For attention:**<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>**For cognitive curiosity:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For effort:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4) | **For long-term relevance:**<br>- A very low/low feeling of learning throughout the stage<br>- A high feeling of fun when doing the task in the game (#4)<br>- A low feeling of fun when the explanation about the task was given (#5)<br>(A decrease in the feeling of fun in this stage)<br>**For attention:**<br>- A high attention towards the imagery throughout the stage<br>- A high attention towards feedback when it was given during the task (#4)<br>- A very low attention towards the cognitive tool (#5)<br>(Dropping value at the end of the stage)<br>**For cognitive curiosity:**<br>- Varying level of curiosity throughout the stage (from the level of very low to the level of high)<br>(Decreasing value at the end of the stage)<br>**For effort:**<br>- Varying level of effort throughout the stage (from the level of high to the level of low)<br>(Decreasing value at the end of the stage)<br>**For confidence:**<br>- Varying level of effort throughout the stage (from the level of high to the level of low)<br>(Dropping value at the end of the stage) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by giving another task to do<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by giving another task which should be slightly different from the first task<br>**For effort:**<br>- Raised the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>**For confidence:**<br>- Increased the level of confidence by giving another task which should not be too hard compared to the first task |
| G: Provide Fun | | **Long-Term Relevance:**<br>H (#4)<br>L (#5) | | | | |
| Content | | **Long-Term Relevance:**<br>VL (#4)<br>L (#5) | | | | |
| Cognitive Tool (#5) | Cognitive Tool (#4) | **Attention:**<br>AS (#4)<br>VL (#5) | | | | |
| Imagery | | **Attention:**<br>H (#4 - #5) | | | | |
| Feedback (#4) | Feedback (#5) | **Attention:**<br>H (#4)<br>AS (#5) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.8: Case dynamic matrix 2: ‘The First Task’ (snapshot 4 – snapshot 5) of case study 5 (first play)

In the second stage ('The First Task') our game prototype was unfolded[4] to demonstrate how the strategies explained in the previous table could be implemented in the game environment as shown in Table F.8 (column: How Issues in Matrix 1 Resolved). The first task was given to the participant and after the task was finished the explanation about the knowledge embedded in the task was provided. The revelation of the task and the explanation aimed at sustaining/increasing the participant's feeling of fun and raising his feeling to learn by playing the game. Also, it aimed at preserving the very high level of cognitive curiosity and of effort used from the previous stage. The feedback relating to his performance was also given to the participant during the task. A short praise was given for every correct choices and the guided feedback was given for the wrong choices instead. The use of feedback aimed at increasing his confidence when playing in this stage of the game. Furthermore, the colourful scenes and the funny look of the cognitive tool were used in order to raise the attention level of the participant. As a result of this implementation, the values of the participant's motivational states were changed as shown in the column: Underlying Issues (as seen by us). The participant still reported to have a very low feeling to learn from the game. However, he felt highly fun when he was doing the task, but when he was given the explanation about the knowledge embedded in the task, his feeling of fun was reported to drop to a very low level. Nevertheless, he reported to be attracted by the imagery used in this stage of the game and the funny look of the cognitive tool. Also, the participant reported to pay high attention to the feedback given during the task. As for cognitive curiosity, effort and confidence, the participant reported to feel highly curious when the task was given and to use a high effort in doing it. He also reported to feel highly confident when he was doing the task. However, when the explanation was given, the participant reported to have a very low level of curiosity and to use a low effort in trying to understand it. Also, his confidence in doing the following task was reported to drop after he finished reading the explanation. Based on these issues, the strategies were specified as appeared in the column: How to Cope with. The second task was considered to be given to increase the participant's feeling to learn and his feeling of fun. The task would be slightly different from the previous task, but would not be too difficult to raise the level of cognitive curiosity, of effort and of confidence in the next stage. In addition, the imagery used in the second task would be changed to increase the attention level.

[4] The term 'unfold' refers to the use of our game prototype as an example that implemented the anticipated changes in the game features according to the specified strategies.

| ILE Features | | Motivational States | | How Issues in Matrix 2 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>L (#6 - #7) | **Cognitive curiosity:**<br>N/A (#6)<br>L (#7)<br>**Effort:**<br>H (#6)<br>VL (#7)<br>**Confidence:**<br>VH (#6)<br>N/A (#7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- A very low/low feelings of relevance in learning and in having fun throughout the stage (Remaining low level feelings of relevance)<br>**For attention:**<br>- Varying attention level towards the imagery throughout the stage (from the level of high to the level of low)<br>- Not able to tell about the attention towards feedback given in the second task (#6)<br>- A low attention level the cognitive tool (#7) (Remaining low level of attention at the end)<br>**For cognitive curiosity:**<br>- Not able to tell about the curiosity at the start of the stage (#6)<br>- A low level of curiosity at the end of the stage (#7) (Remaining low level of curiosity at the end)<br>**For effort:**<br>- Varying level of effort throughout the stage (from the level of high to the level of very low) (Remaining low level of effort at the end)<br>**For confidence:**<br>- A very high confidence at the start of the stage (#6)<br>- Not able to tell about the confidence at the end of the stage (#7) (Increasing value at the beginning) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Raised the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>VL (#6)<br>L (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>L (#6 - #7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>L (#7) | | | | |
| Imagery | | **Attention:**<br>H (#6)<br>L (#7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>N/A (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.9: Case dynamic matrix 3: ‘The Second Task’ (snapshot 6 – snapshot 7) of case study 5 (first play)

Table F.9 (column: How Issues in Matrix 2 Resolved) shows how the strategies explained earlier could be implemented in the game environment (considering our game prototype as an example). The participant was presented with the second task and the explanation about the knowledge in the task. The task aimed at increasing his feeling to learn and his feeling of fun. It was also expected to be able to raise the level of his cognitive curiosity and of effort. Similar to the first task, the participant was given the feedback concerning his performance when doing the task in order to increase his confidence. The theme of the scene was also changed to raise his attention. As a result of this implementation, the values of the participant's motivational states were reported to change as can be seen from the column: Underlying Issues (as seen by us). Still, the participant reported to have a low feeling to learn from the game. His feeling of fun was also reported to be low. However, he reported to be attracted by the imagery used at the beginning of the stage, but not to the funny look of the cognitive tool. As for feedback, the participant was not able to report his attention paid to this feature in this stage. During the second task the participant was also not able to report the level of his cognitive curiosity, but he reported to use a high effort and felt a very high confidence when doing the task. However, a low level of cognitive curiosity and of effort was reported when the explanation about the task was given and he was not able to tell about the confidence level after finishing reading the explanation. The strategies were specified in order to deal with these issues as can be seen from the column: How to Cope with. It was considered that the game should increase the participant's feeling of fun and his feeling to learn; also, the game should raise the level of cognitive curiosity, of effort and of confidence in the next stage. In order to achieve this, the feature: content, was exploited. Two choices were considered in making use of this feature: offering a new task or continuing the story. It was considered that continuing the story seems to be the more appropriate choice (see section 7.3.3.2 for the same explanation as given for case study 1). As a result of this choice, it seems that the feeling to learn of the participant in the next stage might not be affected since no more tasks would be given to the participant. In addition, the feature: imagery was exploited in order to increase the attention of the participant.

Table F.10 (column: How Issues in Matrix 3 Resolved) shows how the strategies explained in the previous matrix could be implemented in the game environment (considering our game prototype as an example). The ending of the story was revealed. The revelation of the ending aimed at increasing the participant's feeling of fun and the level of his cognitive curiosity as it was reported to be low at the end of the previous stage. Also, the colourful scene was presented once again to draw the attention of the participant and to raise the level of effort and of confidence in this stage. As a result of this implementation, the participant reported to have a high feeling of fun and felt highly confident in this stage. He also reported to feel a high coherency in the storyline of the game. However, his feeling to learn from the game was reported to be very low and he was not able to report the level of attention paid to the scenes and of effort used in playing the game at this point. Similar to case study 4, when he was asked to report his overall motivation after the game was finished, he reported to feel motivated to play with the game, but not to learn from it (unsatisfying outcome). Thus, he was asked to play the adjusted version of the game that he just finished.

| ILE Features | | Motivational States | | How Issues in Matrix 3 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:** VL | **Cognitive curiosity:** L<br>**Effort:** N/A<br>**Confidence:** VH | **For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene - Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For long-term relevance:**<br>- A very low feeling of learning in the last stage<br>(Remaining low value from the previous stage)<br>- A high feeling of fun in the last stage<br>(Increasing value from the previous stage)<br>**For attention:**<br>- Not able to tell about the attention paid to the imagery used in this stage<br>**For cognitive curiosity:**<br>- A low level of curiosity in the last stage<br>(Remaining low level of curiosity in this stage)<br>**For effort:**<br>- Not able to tell about the level of effort used in this stage<br>**For confidence:**<br>- A very high confidence in this stage<br>(Sustaining value from the previous stage) | - Resulted in unsatisfying outcome (the participant was finally not motivated to learn with the game environment)<br>- Assigned the participant to play with the adjusted version of this game |
| G: Provide Fun | | **Long-Term Relevance:** H | | | | |
| Content | | **Long-Term Relevance:** VH | | | | |
| | Cognitive Tool | **Attention:** AS | | | | |
| Imagery | | **Attention:** N/A | | | | |
| | Feedback | **Attention:** AS | | | | |

Sources:     Post-questionnaire, retrospective self-report and semi-structured interview

Table F.10:   Case dynamic matrix 4: 'The Finale' (snapshot 8) of case study 5 (first play)

Tables F.11, F.12, F.13 and F.14 were developed for displaying how the features of the adjusted version of the game cause changes in the values of the participant's motivational states. In the adjusted version the imagery used in 'The First Task' and 'The Second Task' stage was changed evidently. More colourful graphics were used and the process of moving the chests to the storehouses/wagons was more visible. These changes did not seem to have a strong effect on the motivational states of the participant since he still reported to have a low feeling to learn from this second game. His feeling of fun was reported to drop from when he played the first game. The attention paid to different features of the game was also reported to drop and a lower level of effort was reported to be used when playing the second game. When the participant was asked to report his overall motivation at the end of the game, he still reported to feel motivated to play the game, but not to learn from it which was the same as his reaction to the first game.

| ILE Features | | Motivational States | | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | |
| G: Support Learning | | **Long-Term Relevance:**<br>L (#1, #3)<br>VL (#2) | **Cognitive curiosity:**<br>N/A (#1 - #2)<br>H (#3)<br>**Effort:**<br>L (#1)<br>N/A (#2)<br>H (#3)<br>**Confidence:**<br>N/A (#1)<br>VH (#2)<br>H (#3) | **For long-term relevance:**<br>- A very low/low feeling of learning throughout the stage<br>- Not able to tell about the feeling of fun at the start (#1) and at the end (#3) of the stage<br>- A very low feeling of fun when the participant was asked to complete a task (#2)<br>**For attention:**<br>- A low value throughout the stage<br>**For cognitive curiosity:**<br>- Not able to tell about the value earlier in the stage (#1 - #2)<br>- A high value at the end of the stage (#3)<br>**For effort:**<br>- A low value at the start of the stage (#1)<br>- Not able to tell about the value at the middle of the stage (#2)<br>- A high value at the end of the stage (#3)<br>**For confidence:**<br>- Not able to tell about the value at the start of the stage (#1)<br>- A very high value at the middle of the stage (#2)<br>- A high value at the end of the stage (#3) | **For long-term relevance:**<br>- Increased the feeling of learning and the feeling of fun by presenting the knowledge embedded in the game and including more fun elements (surprised events (in consideration of the coherency of the story)/interactive activities)<br>**For attention:**<br>- Raised the level of attention by using more colourful graphics in the following scenes<br>**For cognitive curiosity:**<br>- Sustained/increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Maintained/raised the level of effort by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Preserved/increased the level of confidence by making use of the feature: content |
| G: Provide fun | | **Long-Term Relevance:**<br>N/A (#1, #3)<br>VL (#2) | | | |
| Content | | **Long-Term Relevance:**<br>L (#1 - #3) | | | |
| | Cognitive Tool | **Attention:**<br>AS (#1 - #3) | | | |
| Imagery | | **Attention:**<br>L (#1 - #3) | | | |
| | Feedback | **Attention:**<br>AS (#1 - #3) | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.11: Case dynamic matrix 1: ‘The Prelude’ (snapshot 1 – snapshot 3) of case study 5 (second play)

| ILE Features | | Motivational States | | How Issues in Matrix 1 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>VL (#4)<br>L (#5) | **Cognitive curiosity:**<br>N/A (#4)<br>VL (#5)<br>**Effort:**<br>N/A (#4)<br>L (#5)<br>**Confidence:**<br>VH (#4)<br>VL (#5) | **For long-term relevance:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For attention:**<br>- Used more colourful scene (#4)<br>- Used the funny look for the cognitive tool (Mushyman) when explaining about the knowledge embedded in the task (#5)<br>**For cognitive curiosity:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For effort:**<br>- Revealed the first task (#4)<br>- Provided an explanation about the task (#5)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#4) | **For long-term relevance:**<br>- A very low/low feeling of learning and of fun throughout the stage<br>(Remaining low feelings of relevance)<br>**For attention:**<br>- Not able to tell about the attention towards the changes in the imagery at the start of the stage (#4)<br>- Not able to tell about the attention towards feedback when it was given during the task (#4)<br>- A low level of attention towards the cognitive tool (#5)<br>(Remaining low level of attention at the end)<br>**For cognitive curiosity:**<br>- Not able to tell about the curiosity at the start of the stage (#4)<br>- A very low level of curiosity at the end of the stage (#5)<br>(Decreasing value at the end of the stage)<br>**For effort:**<br>- Not able to tell about the effort used at the start of the stage (#4)<br>- A low level of effort used at the end of the stage (#5)<br>(Decreasing value at the end of the stage)<br>**For confidence:**<br>- Varying level of effort throughout the stage (from the level of very high to the level of very low)<br>(Dropping value at the end of the stage) | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by giving another task to do<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by giving another task which should be slightly different from the first task<br>**For effort:**<br>- Raised the level of effort used in the consecutive scenes by giving another task that encouraged thinking<br>**For confidence:**<br>- Increased the level of confidence by giving another task which should not be too hard compared to the first task |
| G: Provide Fun | | **Long-Term Relevance:**<br>VL (#4)<br>L (#5) | | | | |
| Content | | **Long-Term Relevance:**<br>VL (#4)<br>N/A (#5) | | | | |
| Cognitive Tool (#5) | Cognitive Tool (#4) | **Attention:**<br>AS (#4)<br>VL (#5) | | | | |
| Imagery | | **Attention:**<br>N/A (#4)<br>L (#5) | | | | |
| Feedback (#4) | Feedback (#5) | **Attention:**<br>N/A (#4)<br>AS (#5) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.12: Case dynamic matrix 2: 'The First Task' (snapshot 4 – snapshot 5) of case study 5 (second play)

| **ILE Features** | | **Motivational States** | | **How Issues in Matrix 2 Resolved:** | **Underlying Issues (as seen by us)** | **How to Cope with** |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:**<br>L (#6 - #7) | **Cognitive curiosity:**<br>L (#6)<br>VL (#7)<br>**Effort:**<br>N/A (#6)<br>L (#7)<br>**Confidence:**<br>N/A (#6 - #7) | **For long-term relevance:**<br>- Revealed the second task (#6)<br>- Provided an explanation about the task (#7)<br>**For attention:**<br>- Changed the theme of the scene (#6)<br>**For cognitive curiosity:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For effort:**<br>- Revealed the second task (similar to the first task, but with different scenario) (#6)<br>- Provided an explanation about the task (#7)<br>**For confidence:**<br>- Gave a short praise for correct choices and guided feedback for wrong choices (#7) | **For long-term relevance:**<br>- A very low/low feelings of relevance in learning and in having fun throughout the stage<br>(Remaining low feelings of relevance in this stage)<br>**For attention:**<br>- Not able to tell about the attention towards the changes in the imagery at the start of the stage (#4)<br>- Not able to tell about the attention towards feedback when it was given during the task (#4)<br>- A low level of attention towards the cognitive tool (#5)<br>(Remaining low level of attention at the end)<br>**For cognitive curiosity:**<br>- A very low/low level of curiosity throughout the stage<br>(Remaining low level of curiosity in this stage)<br>**For effort:**<br>- Not able to tell about the effort used at the start of the stage (#4)<br>- A low level of effort used at the end of the stage (#5)<br>(Remaining low level of attention at the end)<br>**For confidence:**<br>- Not able to tell about the confidence throughout the stage | **For long-term relevance:**<br>- Increased the feelings of long-term relevance by making use of the feature: content<br>**For attention:**<br>- Raised the level of attention by making use of the feature: imagery<br>**For cognitive curiosity:**<br>- Increased the level of curiosity by making use of the feature: content<br>**For effort:**<br>- Raised the level of effort used in the following scene by involving an activity which required more actions or thinking<br>**For confidence:**<br>- Increased the level of confidence by making use of the feature: content |
| G: Provide Fun | | **Long-Term Relevance:**<br>VL (#6)<br>L (#7) | | | | |
| Content | | **Long-Term Relevance:**<br>L (#6)<br>N/A (#7) | | | | |
| Cognitive Tool (#7) | Cognitive Tool (#6) | **Attention:**<br>AS (#6)<br>VL (#7) | | | | |
| Imagery | | **Attention:**<br>N/A (#6)<br>L (#7) | | | | |
| Feedback (#6) | Feedback (#7) | **Attention:**<br>N/A (#6)<br>AS (#7) | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.13: Case dynamic matrix 3: 'The Second Task' (snapshot 6 – snapshot 7) of case study 5 (second play)

| ILE Features | | Motivational States | | How Issues in Matrix 3 Resolved: | Underlying Issues (as seen by us) | How to Cope with |
|---|---|---|---|---|---|---|
| **Presented Features** | **Absent Features** | **Initial States** | **Consecutive States** | | | |
| G: Support Learning | | **Long-Term Relevance:** VL | **Cognitive curiosity:** N/A<br>**Effort:** N/A<br>**Confidence:** H | **For long-term relevance:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For attention:**<br>- Presented the colourful scene - Emma's house – once again<br>**For cognitive curiosity:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma)<br>**For effort:**<br>- Involved an action from the participant in controlling the main character – Alex<br>**For confidence:**<br>- Revealed the ending of the story (Succeeded in bringing back medicine and got a praise from a friend – Emma) | **For long-term relevance:**<br>- A very low feeling of learning in the last stage (Dropping value from the previous stage)<br>- A high feeling of fun in the last stage (Increasing value from the previous stage)<br>**For attention:**<br>- Not able to tell about the attention paid to the imagery used in the last stage<br>**For cognitive curiosity:**<br>- Not able to tell about the value in the last stage<br>**For effort:**<br>- Not able to tell about the level of effort used in the last stage<br>**For confidence:**<br>- A high confidence in the last stage (Increasing value from the previous stage) | - Resulted in unsatisfying outcome (the participant was still not motivated to learn with the adjusted game environment) |
| G: Provide Fun | | **Long-Term Relevance:** H | | | | |
| Content | | **Long-Term Relevance:** H | | | | |
| | Cognitive Tool | **Attention:** AS | | | | |
| Imagery | | **Attention:** N/A | | | | |
| | Feedback | **Attention:** AS | | | | |

Sources: Post-questionnaire, retrospective self-report and semi-structured interview

Table F.14: Case dynamic matrix 4: 'The Finale' (snapshot 8) of case study 5 (second play)

### F.3.3 The Revised Causal Model

Figure F.7 shows the revised causal model of motivation of the case. The model demonstrates the ILE features, the motivational variables and the relationships among them in a form of network. The motivational variables and the ILE features are represented by nodes whereas the relationships among them are represented using links. The details about the links can be explained in the same way as in case study 1 (see section 7.3.3.3 for the explanation).

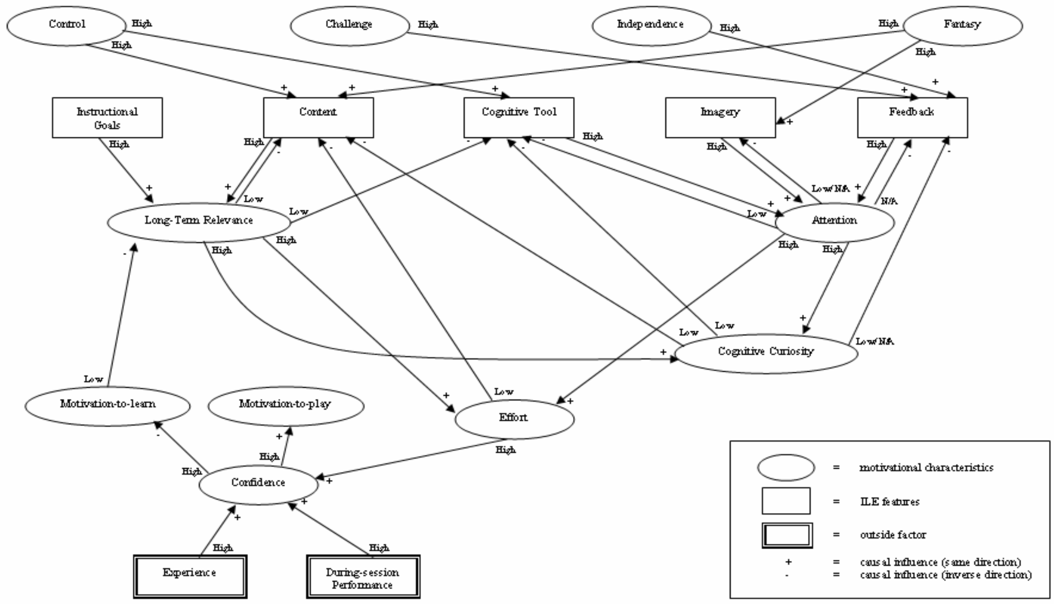


Figure F.7: The revised causal model of motivation of case study 5

The story of the model can be told as two related parts. In the first part the traits of the participant can be viewed as the independent variables whereas the features of the game ILE can be viewed as the dependent variables (or variables that vary according to the trait characteristics). The story of this part starts when the participant reported about his trait characteristics in a learning environment that he preferred to have control over the learning materials and he enjoyed challenging situations. Furthermore, he preferred to be independent when learning; that is, he preferred not to get help from the tutor and would rather like to succeed by himself. Hence, he was assigned by MoRes to play Alex's Adventure 2.0 in which he could have control over some parts of the game content and the cognitive tool (which was also considered to be a part of the content as explained in case study 1). In addition, if the participant made a mistake when doing the tasks, he would be given the guided feedback that told him implicitly about what was supposed to be right. This design attempts to make the game better matched with the high-control, high-challenge and high-independent characteristics of the participant.

In the ILE features – state characteristics part the features of the game and the states of the participant can be viewed as both the independent and the dependent variables as explained in case study 1. The story of this part begins when the participant started the interaction with the game environment.

According to the data (see Figures F.1 and F.2 for the plots of attention, Figures F.3 and F.4 for the plots of relevance and Figures F.5 and F.6 for the plots of cognitive curiosity, effort and confidence), there are fluctuations appeared in the graphs in those plots which shows that the values of the participant's motivational states can vary according to the scenes presented; some similarities and some differences do exist among these scenes; hence, some of them may contain the same features and some of them may consist of different features. That is, the features included in a single scene could play an important role in changes in the values of the motivational states. Hence, it was considered that the features of the game environment could exert some influences on the motivational states of the participant.

According to the plots of attention in the first and the second play (see Figures F.1 and F.2), it was considered that generally, the use of imagery in the game ILE could attract the attention of the participant instantly in the first play and hence, a link was drawn from the feature: imagery, to attention to represent this relationship. However, there were a few points in the first play where the participant was not able to report his attention or his attention was reported to be low; this might be because the scene presented was less colourful or was similar to the scene presented earlier. However, in the second game the participant reported to feel less attracted to the imagery since in his opinion only some scenes in the game were changed. As a result, another link was drawn backward from attention to the feature: imagery, in order to show that this feature could be adjusted in order to raise the attention of the participant. The appearance of the cognitive tool after the first task in the first game could also catch his attention immediately. However, he reported not to feel attracted to its explanation and when the tool appeared again after the second task of the first game, the participant reported to pay low attention to this feature. Similarly, when the tool was presented after each task in the second game was finished, the participant reported to pay less attention to its appearances and its explanations. He made a further suggestion concerning the tool that it should appear before the tasks in order to explain the knowledge used for solving problems in the tasks, not the other way round. It was considered that this might be the reason why the participant reported to pay low attention to the tool and to feel low curious about its explanation which leads to the low motivation to learn at the end of both games. Based on this evidence, a forward arrow was drawn from the feature: cognitive tool, to attention. Furthermore, a backward arrow was drawn from attention to the feature: cognitive tool, to represent the comment from the participant about how the tool could be improved. Feedback given during the tasks in both games was supposed to be able to draw the attention of the participant and it succeeded in doing so in the first task of the first game; however, the participant was not able to report his attention paid to this feature in the second task of the first game and in both tasks of the second game. According to his report, an arrow was drawn from the feature: feedback, to attention to represent the relationship in the first task of the first game. Also, another arrow was drawn backward from attention to the feature: feedback, to show that this feature could be adjusted in order to raise the attention level of the participant.

As can be seen from the plots of relevance in the first and the second play (Figures F.3 and F.4), the graphs showing his feelings that the content of both games was relevant to his goal in learning generally fall into the low-value area which demonstrates his low feeling to learn from the games. As for the feeling of fun, the value of relevance was reported to be high at the last point of the plots which shows his high feeling of fun at the end of the game (he reported that he felt happy to play Alex's Adventure, but he could not learn from doing the tasks in the game). The participant reported through the use of the open-ended questions that, the method of how the knowledge was presented in the game was not efficient. The knowledge should not be explicitly presented after each single task. Rather, it should be presented before the task so that he could gain knowledge to solve problems in the task and this was why he was not motivated to learn from the first game. He expected to see this change in the second game; however, the second game was not changed in such a way and he was also not happy to learn from it. Nevertheless, he felt interested in the game because he was curious about the tasks in the games and wanted to find out how the story would end. He could feel that there was a high coherency in the storyline which could affect his feeling of fun when playing the game. However, the second game could be improved by changing the tasks and the storyline to make it more interesting. Based on his report, two arrows were drawn from the features: instructional goals and content, to long-term relevance to represent the effects caused by these features. Also, another two arrows were drawn backward from long-term relevance to the features: content and cognitive tool, to demonstrate that these features could be adjusted based on the suggestions from the participant.

On the other hand, the other three motivational states: cognitive curiosity, effort and confidence, were considered to be affected by either attention or relevance, or both, according to the literature described in section 4.2.3. Based on the literature and looking from the plot of cognitive curiosity, effort and confidence (Figures F.5 and F.6), the plot of attention (Figures F.1 and F.2) and the plot of relevance (Figures F.3 and F.4), the values of cognitive curiosity, to some extent, were considered to be influenced by the values of either attention or long-term relevance, or both. Thus, two arrows were drawn from the motivational states: attention and long-term relevance, to cognitive curiosity. However, as the participant reported to feel low curious towards the explanations given by the cognitive tool in both tasks and was not happy about the way they were presented in the game, it was considered that the content of the game and the cognitive tool could be adjusted in order to raise the level of his cognitive curiosity. As a result, two arrows were drawn backward from cognitive curiosity to the features: content and cognitive tool, to represent his suggestions. Furthermore, since the participant was not able to report his curiosity towards the feedback given during the second task of the first game and the first task of the second game and he felt low curious when the feedback was given during the second task of the second game, another arrow was drawn backward from cognitive curiosity to the feature – feedback, to show that another way to increase the participant's cognitive curiosity was to adjust this feature.

Similar to cognitive curiosity, effort is the motivational state that was considered to be affected by attention and long-term relevance and the values of effort, to some degree, are likely to be influenced by the values of either attention or long-term relevance, or both (see the explanation of explanatory effects matrix for the details). Therefore, two arrows were drawn from the motivational states: attention and long-term relevance, to effort. Also, according to the explanation, it seems that the level of effort used in playing the games varied depended on what kind of activity/task was offered to him and how difficult it was. As a result, it was considered that to increase the level of effort, the content of the game could be adjusted by offering an activity or a task that required actions or some critical thinking. Based on this, an arrow was drawn from effort to the feature – content, to show this backward relationship.

As for confidence, this motivational state requires a different explanation. According to the plot of cognitive curiosity, effort and confidence (Figures F.5 and F.6), the plot of attention (Figures F.1 and F.2) and the plot of relevance (Figures F.3 and F.4), to some extent, he was attracted to the game or found the relevance between his goal in having fun and the game in the first place which made him tried to progress through the game (as mostly, he reported to use a high level of effort in playing both games) and he was succeeded in both plays which resulted in a high level of confidence when playing in the non-serious part of the game. Hence, an arrow was drawn from effort to confidence to represent this relationship. However, the value of each of these two motivational states is not exactly the same for every single point of the plots and thus, it was considered that the values of confidence might be influenced by the outside factors: during-session performance and experience similar to the other cases. The participant performed very well in the second task of the first game which could be regarded as the reason why he reported to have a high level of confidence when playing the first game in general. However, when he was asked to play the second game, his confidence was low in the scenes that involved with learning ERM which might be because he still had difficulty in learning from the game. Nevertheless, in other scenes, the participant reported to have a high level of confidence which might be because he already gained experience and felt familiar with the game environment from the first play. Based on this consideration, another two arrows were drawn from these two outside factors to confidence.

At the end of the first game the participant reported to feel motivated to play the game, but not to learn from it. Hence, he was asked to play the second game (the adjusted version of the first game). At the end of the second game the participant still reported to feel motivated to play the game, but not to learn from it. It was considered that these data should be presented in the revised version of the model since it provides a better view towards the motivation of the case from both the first and the second play. This consideration leads to the augmentation of the motivation model of the case and the augmentation of the model was done based on the following rules (similar to the other non-motivated cases – case study 4 and case study 6): 1) in the context of educational game, there are two types of motivation: motivation to learn and motivation to play, and it seems not always to be the case that if a learner is motivated to play, he/she will also be motivated to learn as can be seen from the current case; hence, it was considered that motivation should be separated and thus, two nodes were added to the model: motivation to learn and motivation to play. 2) according to Keller’s (1987) ARCS model, motivation is supposed to occur after a learner feels confident; in the first play, the case reported to feel confident when playing the game in a non-serious part and after the play, he reported to feel motivated to play the game, but not to feel motivated to learn from it; based on the ARCS and the result from the first play, two arrows were drawn from confidence to both types of motivation to represent the relationship between the confidence state and the motivation of the case; the arrow with a minus sign was used to represent the high confidence – low motivation-to-learn relationship whereas the arrow with a plus sign is used to represent the high confidence – high motivation-to-play relationship; in the second play, the case also reported to feel highly confident when playing the game and after the play, the case still reported not to feel motivated to learn from playing the game; as a result, another arrow was drawn from motivation-to-learn to long-term relevance; this arrow shows the relationship between motivation-to-learn and long-term relevance that in order to motivate the participant to learn from the game, the value of long-term relevance could be increased by either adjusting the tasks in the game (content) or improving the representation of the knowledge embedded in the tasks (imagery) as mentioned earlier in this section.

## F.4 Summary of Case Study 5

This case was considered to be a special ‘non-motivated’ case since the participant was not motivated to learn after the first game. As a result, he was asked to play the second game which is the adjusted version of the first game and this version succeeded in motivating him to play, but not in motivating him to learn from it.

The participant was asked to provide the trait characteristics in a learning environment and based on his report, MoRes assigned him to play Alex’s Adventure 2.0 which was considered to be the version that suits with his trait characteristics. The trait characteristics of the case were shown in Table F.1. Also, he was asked to report his motivational states during interactions with both games and his overall motivational states after finishing playing each game. The data regarding his motivational states during both interactions was presented using the event listing tables (Tables F.2 and F.3) and the plots of motivational states (Figure F.1 – Figure F.6). The effects matrix of ILE features (Table F.4) was also used to describe the effects of the game features on the motivational states of the case in both plays. The causal mechanisms between the trait characteristics, the features of the game and the state characteristics in both plays were revealed using the explanatory effects matrices (Tables F.5 and F.6) and eight case dynamic matrices (Table F.7 – Table F.14). The revised causal model of motivation of the case is also created to present these causal mechanisms in a coherent picture (Figure F.7).

Some key findings can be drawn from the study of this case as shown in the bullet points below.

- In the context of educational game motivation can be separated into two types: motivation-to-learn and motivation-to-play.
- In the context of educational game if one is motivated to play, it is not always the case that he/she will be motivated to learn as well.
- To develop the motivation in learning, the feelings of long-term relevance were supposed to be raised and the viable methods that seems to work for this case is to adjust the way in which the knowledge was presented explicitly to the participant (e.g. presenting the cognitive tool before the task) and to change the content of the game to preserve the level of interest throughout the game (e.g. making the second task more different from the first task).

- To raise the attention level, the features: imagery, cognitive tool and feedback, could be adjusted (e.g. changing scenes, changing the feedback style).
- To increase the cognitive curiosity, the features: feedback, cognitive tool and content, could be adjusted (e.g. changing the storyline).
- To increase the level of effort used in the game ILE, the feature: content, could be adjusted (e.g. including a more complicated activity/task).
- Similar to the other cases, confidence was the motivational state that might be influenced by the outside factors (experience and during-session performance); however, it was not evident whether the other motivational states could be influenced by the outside factors.

# Appendix G

# Checklist Matrix on Facial Expressions and Gestures

This appendix presents checklist matrix on facial expressions and gestures created for case study 1 – case study 6. The matrix describes the data obtained from two sources: webcam and observational notes. The data is described in two aspects: facial expressions and gestures; for each aspect, we chose to present the data in a narrative form as it was considered to be more flexible and it could provide a rich description of the motivational appearance of each case.

# G.1 Checklist Matrix on Facial Expressions and Gestures of Case Study 1

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Looked aware of the presence of webcam when started playing the game (glance a bit at the top position of the screen) (:F1), but as time passed by, he seemed like not being aware of the use of webcam anymore (:F2)<br>- Stared at screen all the time (did not look anywhere else) (:F3)<br>- Moved his eyes along the screen at various points in the game (:F4)<br>- Once raised one of his eye brow and smiled a bit (:F5)<br>- Looked a bit serious at some points in the game (:F6)<br>- Licked and compressed his lips at some points in the game and seemed to think hard (:F7) | |
| **Gestures** | - Looked a bit anxious when started using the system (moved the top part of his body a few times) (:G1)<br>- Nodded his head once during playing the game (as if he was saying 'Ok, I understand.' (:G2) | - Seemed to think carefully when doing tasks in the game (checking for the relevant information before making each move) (:G3)<br>- Moving a mouse along an explanation about what database knowledge was represented by those tasks (:G4) |
| **Others** | | |

# G.2 Checklist Matrix on Facial Expressions and Gestures of Case Study 2

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Looked aware of an observer when started playing the game (glance a bit in the direction where the observer was sitting) **(:F1)**, but seemed not to be aware of the observer anymore as progressed through the game for a short while **(:F2)**<br>- Raised his eyebrow once at the beginning of the game (after a video started recording for 3 – 4 minutes **(:F3)**<br>- Smiled 4 -5 times during playing the game **(:F4)**<br>- Stared at screen all the times **(:F5)**<br>- Moved his eyes along the screen at various points in the game **(:F6)**<br>- Looked a bit serious at some points in the game **(:F7)**<br>- Looked a bit relieved at the end of the game **(:F8)** | |
| **Gestures** | - Moved his top body closer to the screen **(:G1)**<br>- Touched his chin at some points in the game and seemed to think hard **(:G2)** | - Seemed to think carefully when doing the first task in the game (checking for the relevant information before making each move) **(:G3)**, but played the game by guessing a bit at nearly the end of the second task **(:G4)**<br>- Spent a long time in reading an explanation about the database knowledge represented by those tasks **(:G5)** |
| **Others** | | |

# G.3 Checklist Matrix on Facial Expressions and Gestures of Case Study 3

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Moved her eyes along the screen at various points in the game **(:F2)**<br>- Smiled a few times during playing the game and had a little laugh once**(:F3)**<br>- Looked a bit serious at some points in the game **(:F4)**<br>- Compressed her lips at some points in the game and seemed to think hard **(:F5)**<br>- Raised her eyebrows once when finishing playing the game and looked relieved **(:F6)** | |
| **Gestures** | - Moved her top body closer to the screen and seemed to concentrate more **(:G1)**<br>- Touched her mouth at some points in the game and seemed to think hard **(:G2)** | -Looked confused about the use of controls at the beginning **(:G3)**<br>- Made some voices like murmured to herself in some scenes of the game **(:G4)**<br>- Seemed to think carefully when doing both tasks in the game (checking for the relevant information before making each move) **(:G5)**<br>- Moving a mouse along an explanation about what database knowledge was represented by the first task **(:G6)**<br>- Chose not to see the explanation about the second task at first, but after getting a persuasion from a cognitive tool (Mushyman), changed her mind **(:G7)** |
| **Others** | | |

# G.4 Checklist Matrix on Facial Expressions and Gestures of Case Study 4

## G.4.1 Checklist Matrix on Facial Expressions and Gestures (First Play)

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Moved his eyes along the screen at various points in the game **(:F2)**<br>- Smiled a few times during playing the game **(:F3)**<br>- Looked highly concentrated in playing the game **(:F4)**<br>- Compressed his lips at some points in the game and seemed to think hard **(:F5)** | |
| **Gestures** | - Moved his top body closer to the screen and seemed to concentrate more **(:G1)**<br>- Touched his chin and his mouth at some points in the game and seemed to think hard **(:G2)**<br>- Nodded his head twice during playing the game **(:G3)** | - Seemed to think carefully when doing tasks in the game (checking for the relevant information before making each move) **(:G4)**<br>- Moved a mouse along an explanation about the database knowledge embedded in those tasks **(:G5)** |

## G.4.2 Checklist Matrix on Facial Expressions and Gestures (Second Play)

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Moved his eyes along the screen at various points in the game **(:F2)**<br>- Looked concentrated in playing the game **(:F3)** | |
| **Gestures** | - Moved his top body closer to the screen and seemed to concentrate more **(:G1)** | - Made a deep voice when seeing the changes in the tasks (different colours used for each chest) **(:G2)**<br>- Seemed to think carefully when doing tasks in the game (checking for the relevant information before making each move) **(:G3)**<br>- Looked alert when he firstly made the right choice in the first task and saw the chest was moving to the storehouse **(:G4)**<br>- Moved a mouse along an explanation about the database knowledge embedded in those tasks **(:G5)**<br>- Clicked the mouse to close the dialog boxes quicker (compared with the first-time play) especially in the scenes in which a small changes was made or there was no change at all **(:G6)** |

# G.5 Checklist Matrix on Facial Expressions and Gestures of Case Study 5

## G.5.1 Checklist Matrix on Facial Expressions and Gestures (First Play)

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Moved his eyes along the screen at various points in the game **(:F2)**<br>- Smiled a few times during playing the game **(:F3)**<br>- Looked concentrated in playing the game **(:F4)** | |
| **Gestures** | - Moved his top body closer to the screen and seemed to concentrate more **(:G1)** | - Seemed to absorb with the game (making some voices along when he met with a guy who worked as a guard for Dr de Ville **(:G2)**<br>- Seemed not to be sure about how to do the first task since he made only two out of five correct choices and when he saw the second task, he asked the observer to confirm about a means of doing it **(:G3)** |

## G.5.2 Checklist Matrix on Facial Expressions and Gestures (Second Play)

| | Data from Webcam | Data from Observation Note |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Moved his eyes along the screen at various points in the game **(:F2)** | |
| **Gestures** | | - Clicked the mouse to close the conversation dialogs quickly, especially in the last scene – 'Back to Emma', the participant just clicked the mouse without reading the conversation dialogs **(:G1)**<br>- Seemed to think when doing tasks in the game (checking for the relevant information before making each move) **(:G2)**<br>- Looked alert when he firstly made the right choice in the first task and saw the chest was moving to the storehouse **(:G3)**<br>- Looked like the participant was still not interested to learn from the game as when he finished doing the second task and he was asked whether he would like to receive the explanation about the task, he chose not to; this leaded him to the 'Trap' scene in which he has no choice, but to receive the explanation in order to get out of the scene **(:G4)** |

# G.6 Checklist Matrix on Facial Expressions and Gestures of Case Study 6

## G.6.1 Checklist Matrix on Facial Expressions and Gestures (First Play)

| | **Data from Webcam** | **Data from Observation Note** |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Looked across the screen at various points in the game **(:F2)**<br>- Looked concentrated in playing the game **(:F3)**<br>- Compressed her lips at some points in the game and seemed to think **(:F4)** | |
| **Gestures** | - Moved her top body closer to the screen and seemed to concentrate **(:G1)** | - Seemed to think carefully when doing the first task in the game (checking for the relevant information before making each move) **(:G2)**; nearly at the end of the second task, did the task by guessing **(:G3)**<br>- Spend time on reading an explanation about the database knowledge embedded in the first task **(:G4)**; after finishing the second task, chose not to see the explanation, but changed her mind later **(:G5)** |

## G.6.2 Checklist Matrix on Facial Expressions and Gestures (Second Play)

| | **Data from Webcam** | **Data from Observation Note** |
|---|---|---|
| **Facial Expressions** | - Stared at the screen all the time **(:F1)**<br>- Moved her eyes along the screen at various points in the game **(:F2)**<br>- Looked bored **(:F3)** | |
| **Gestures** | - Touched her hair a few times and seemed slightly uncomfortable **(:G1)** | - Clicked the mouse to close the conversation dialogs very quickly **(:G2)**<br>- Seemed to think when doing the tasks in the game (checking for the relevant information before making each move) **(:G3)**<br>- Looked slightly alert when first made the right choice in the first task and saw the chest was moving to the storehouse and when finished the task and a firework was presented as a reward for completing the task without making any error **(:G4)**; however, after the first right choice, she chose to move the next chest without waiting for the one that had been chosen before finished its moving **(:G5)**<br>- Looked very bored when seeing the appearance of the cognitive tool after finishing the first task and chose not to receive the explanation which leaded her to the ‘Dark Forest’ scene **(:G6)**; after finishing the second task, chose to receive the explanation, but clicked the mouse to close the explanation dialogs very quickly **(:G7)** |

# Appendix H

# Plots of Motivational States of ‘Learners’

This appendix presents the plots of motivational states for the ‘learners’ group. The plots demonstrate a change in the value of each motivational state during interaction with the game.

# H.1 Plots of Attention Value of 'Learners'

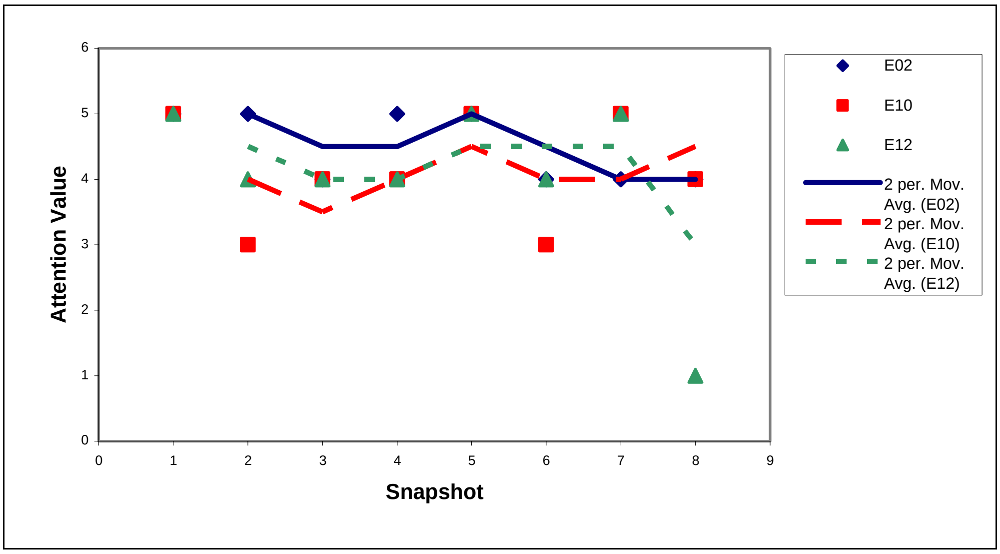


Figure H.1.1: Plots of attention value towards imagery of 'Learners'

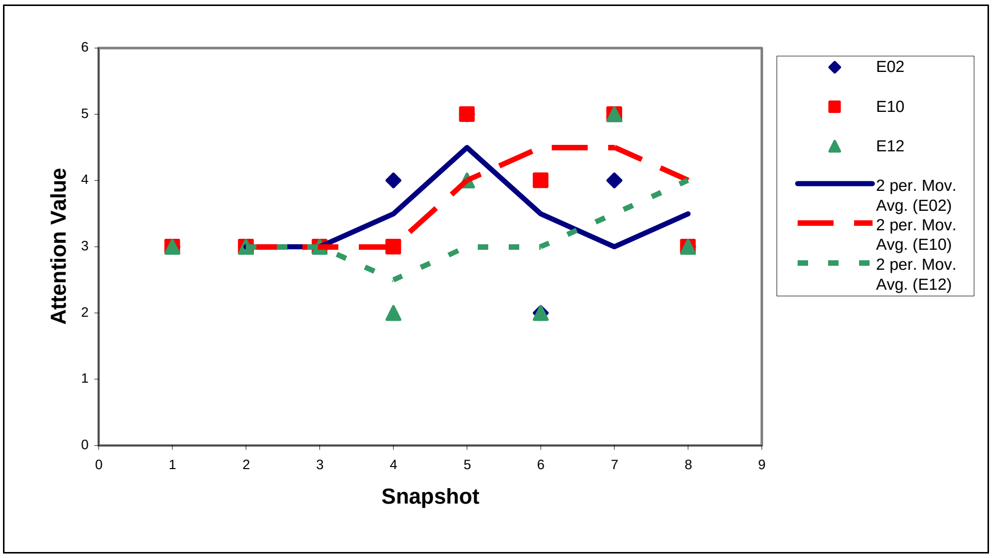


Figure H.1.2: Plots of attention value towards feedback and cognitive tool of 'Learners'

# H.2 Plots of Relevance Value of 'Learners'

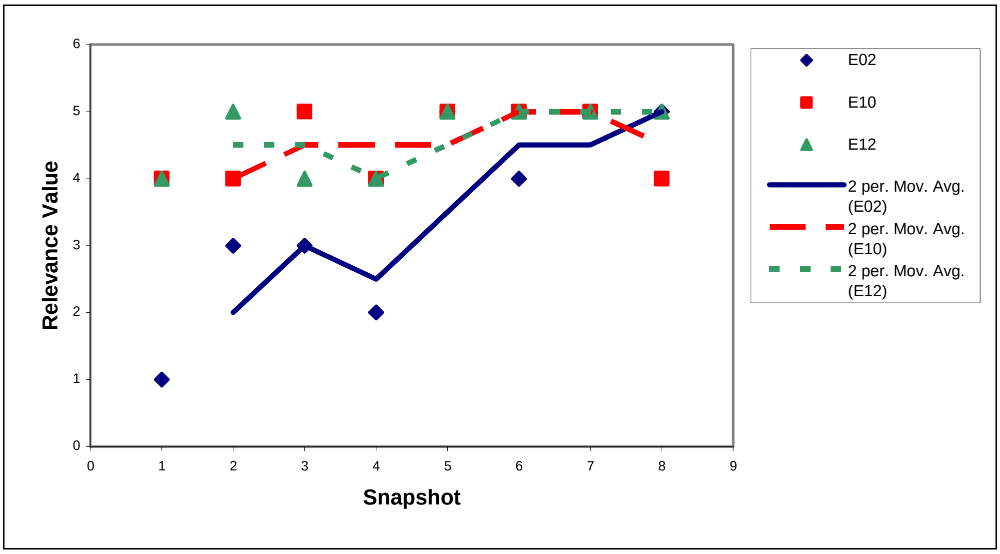


Figure H.2.1: Plots of relevance value towards the instructional goal: support learning of 'Learners'

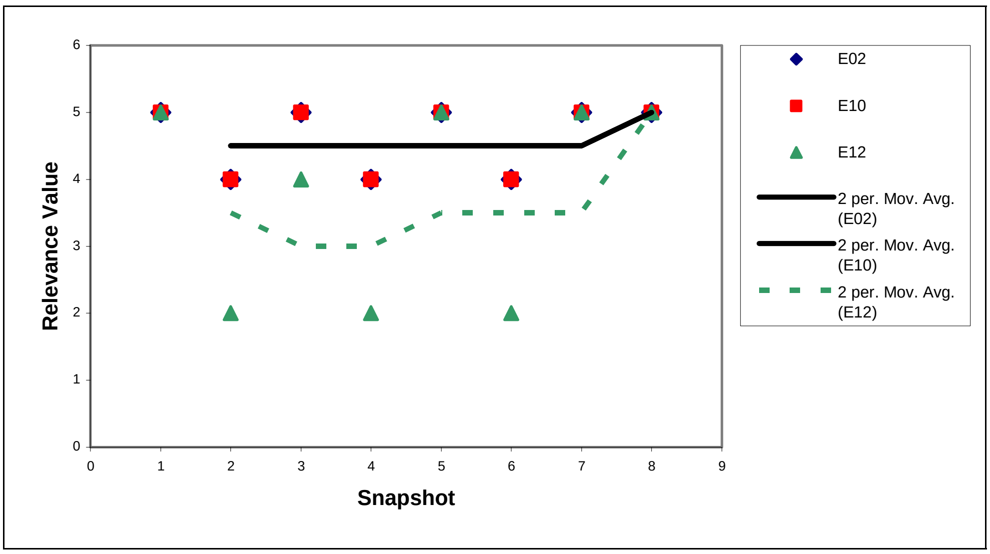


Figure H.2.2: Plots of relevance value towards the instructional goal: provide fun of 'Learners'

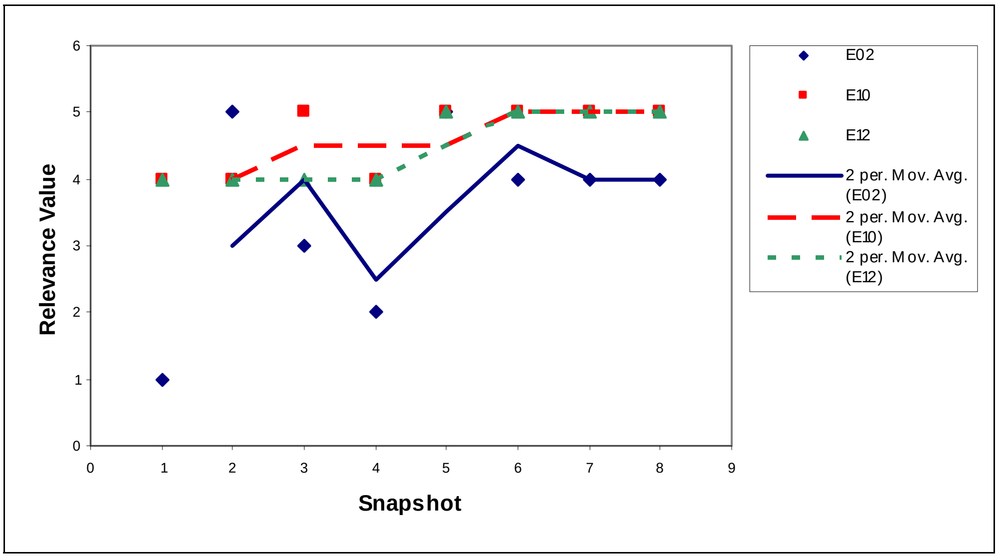


Figure H.2.3: Plots of relevance value towards content of 'Learners'

# H.3 Plots of Cognitive Curiosity Value of 'Learners'

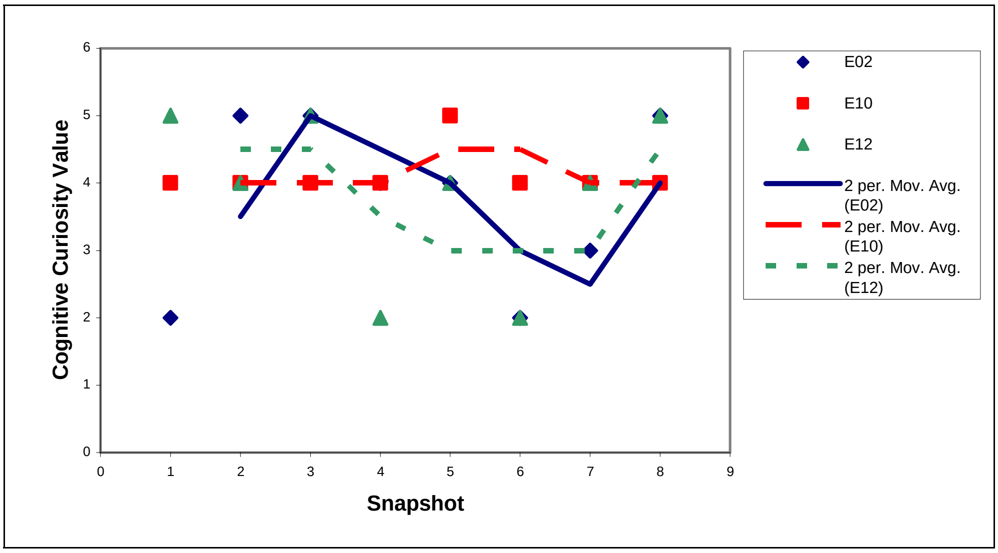


Figure H.3.1: Plots of cognitive curiosity value of 'Learners'

# H.4 Plots of Effort Value of 'Learners'

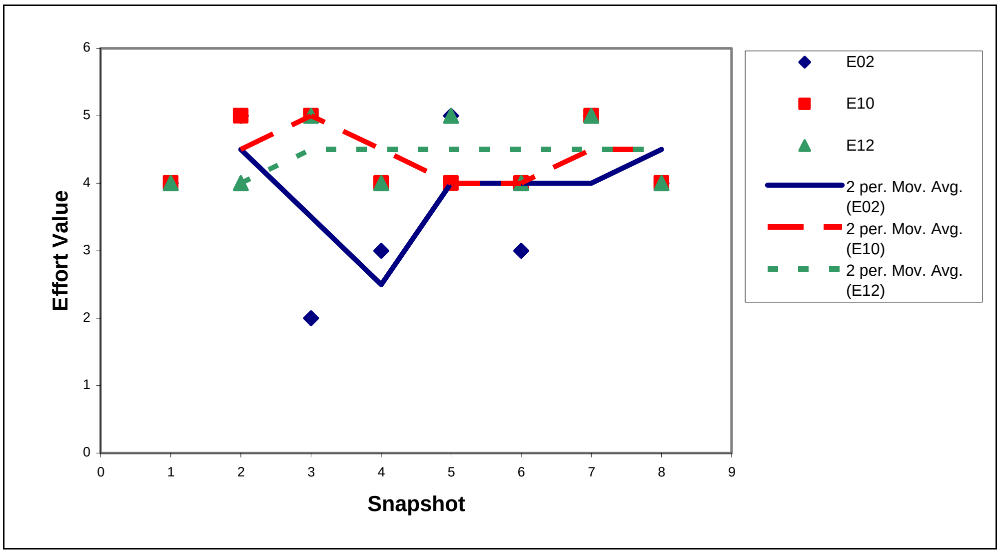


Figure H.4.1: Plots of effort value of 'Learners'

# H.5 Plots of Confidence Value of 'Learners'

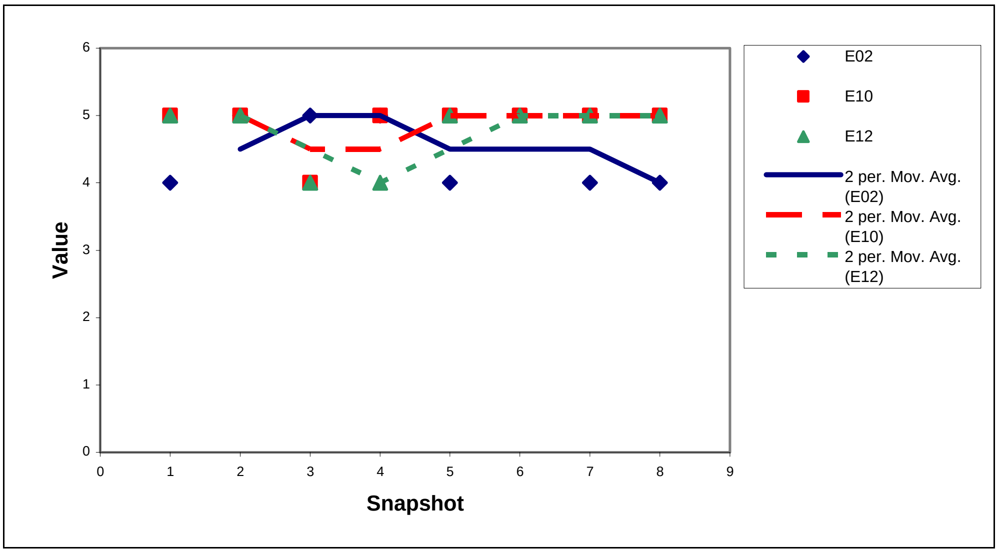


Figure H.5.1: Plots of confidence value of 'Learners'

# Appendix I

# Plots of Motivational States of ‘Non-Learners’

This appendix presents the plots of motivational states for the ‘non-learners’ group. The plots demonstrate a change in the value of each motivational state during interaction with the game.

However, as previously discussed in chapter 8, this group refers to the participants who reported not to feel motivated to learn from playing the game – Alex’s Adventure (the first play). Thus, they were asked to play the second game which was the adjusted version of the first game (the second play). This appendix presents the plots in relation to both plays.

# I.1 Plots of Attention Value of 'Non-Learners'

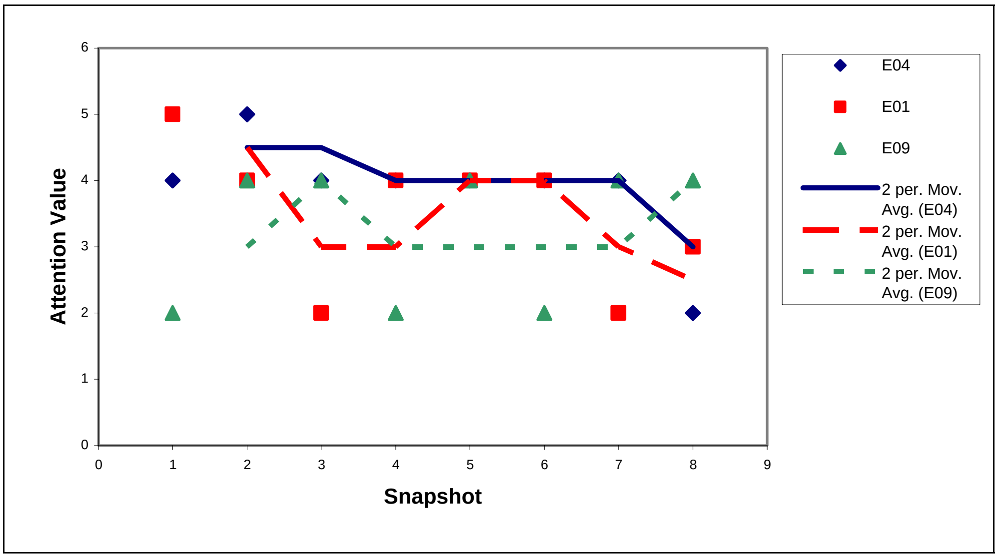


Figure I.1.1: Plots of attention value towards imagery of 'Non-Learners' in the first play

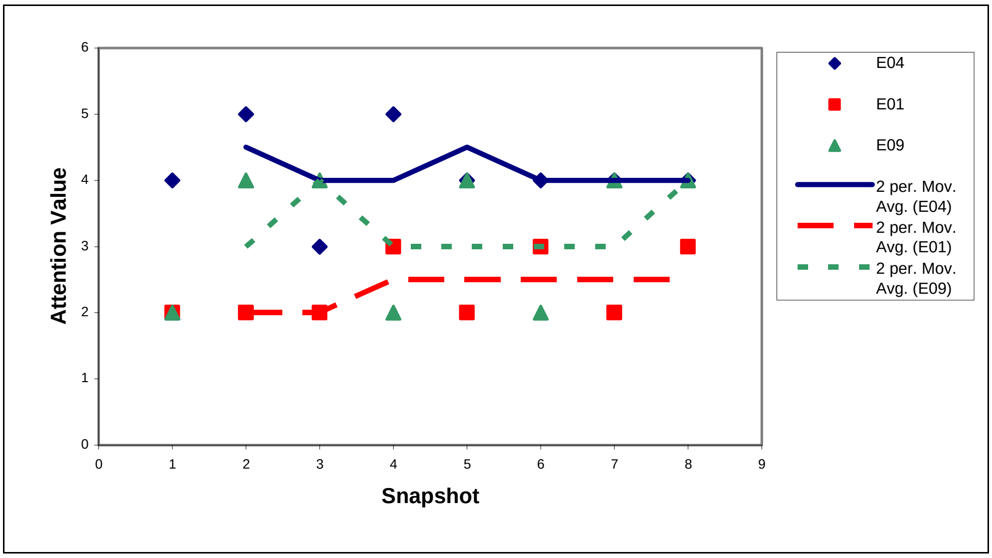


Figure I.1.2: Plots of attention value towards imagery of 'Non-Learners' in the second play

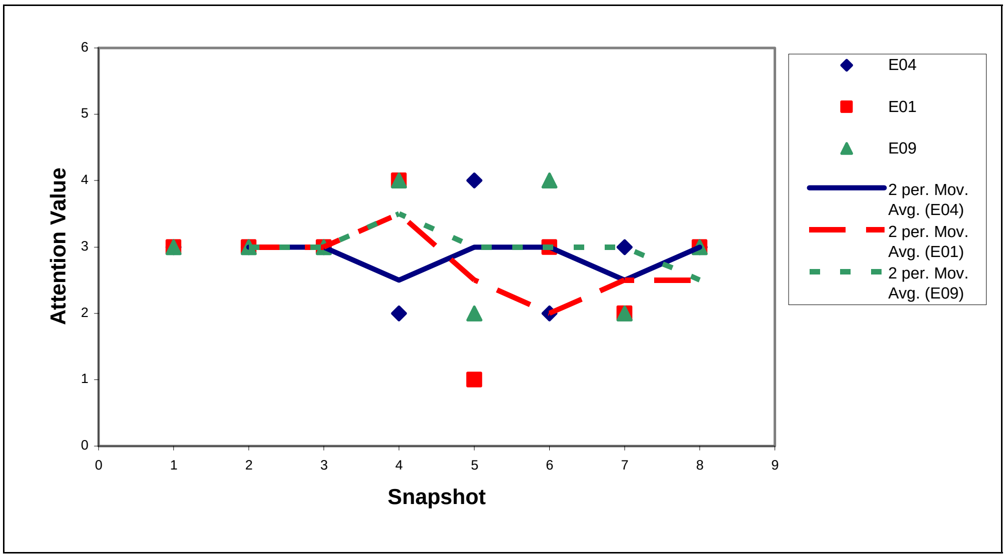


Figure I.1.3: Plots of attention value towards feedback & cognitive tool of 'Non-Learners' in the first play

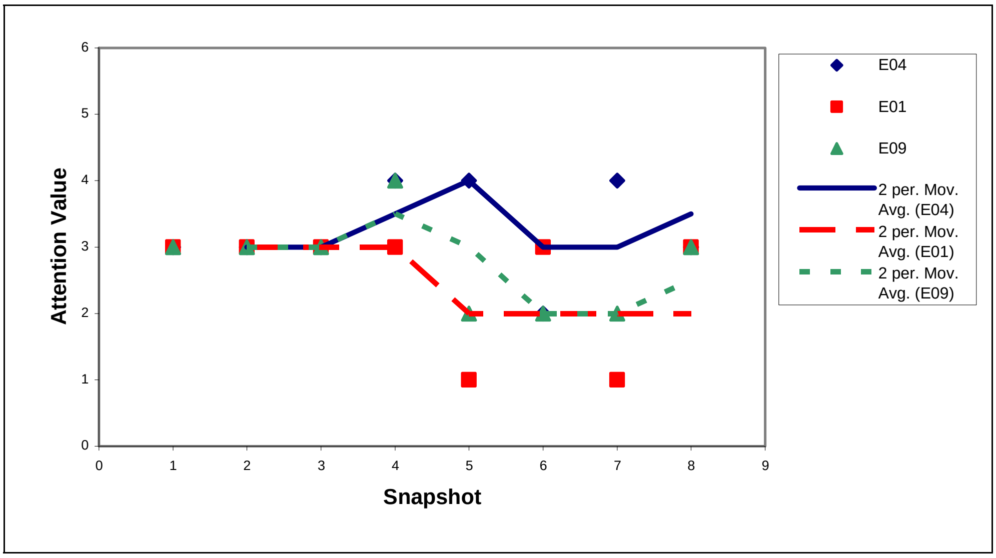


Figure I.1.4: Plots of attention value towards feedback & cognitive tool of 'Non-Learners' in the second play

# I.2 Plots of Relevance Value of 'Non-Learners'

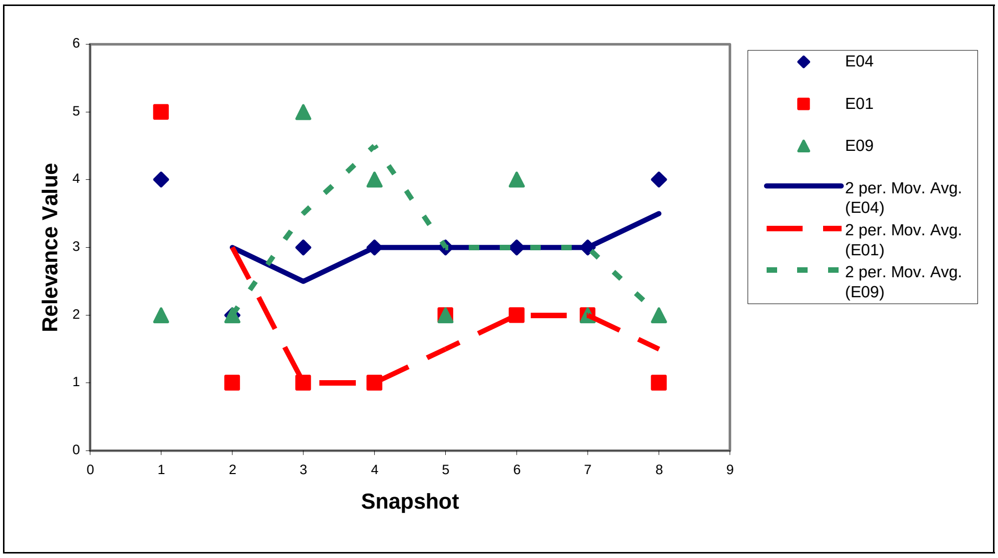


Figure I.2.1: Plots of relevance value towards the instructional goal: support learning of 'Non-Learners' in the first play

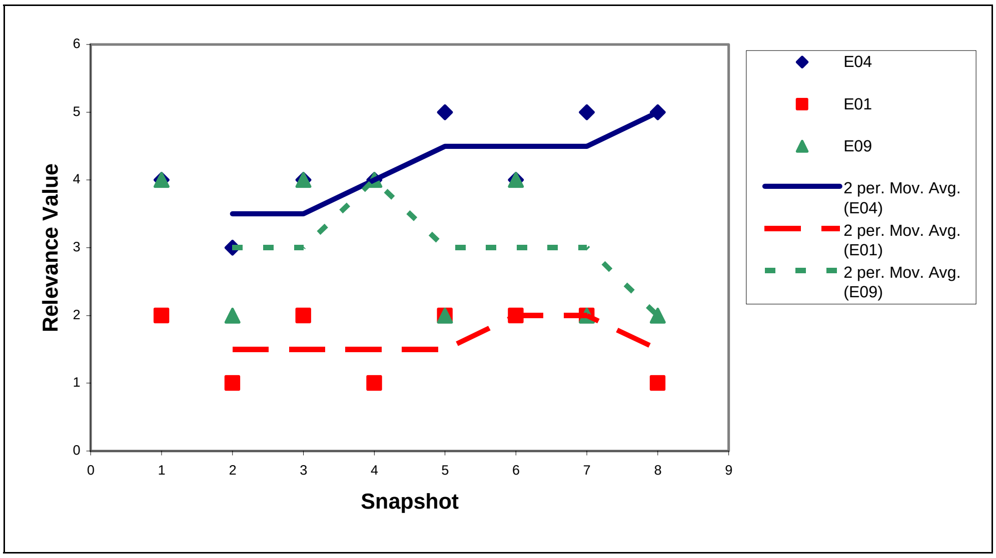


Figure I.2.2: Plots of relevance value towards the instructional goal: support learning of 'Non-Learners' in the second play

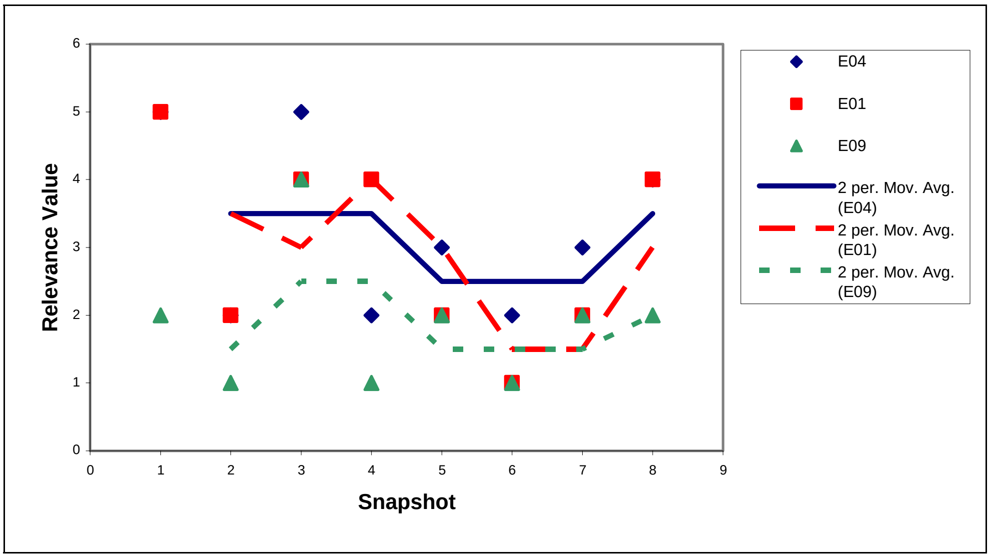


Figure I.2.3: Plots of relevance value towards the instructional goal: provide fun of ‘Non-Learners’ in the first play

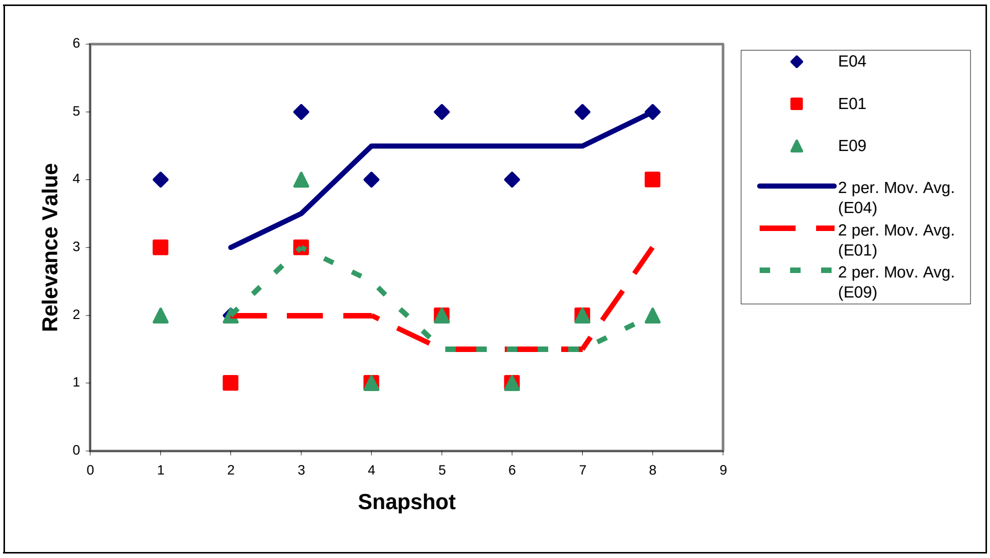


Figure I.2.4: Plots of relevance value towards the instructional goal: provide fun of ‘Non-Learners’ in the second play

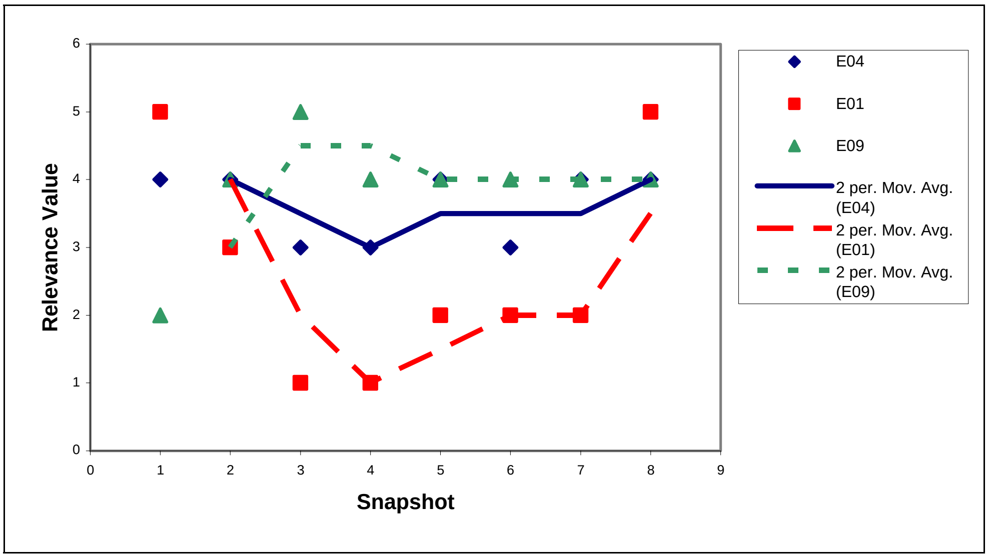


Figure I.2.5: Plots of relevance value towards content of 'Non-Learners' in the first play

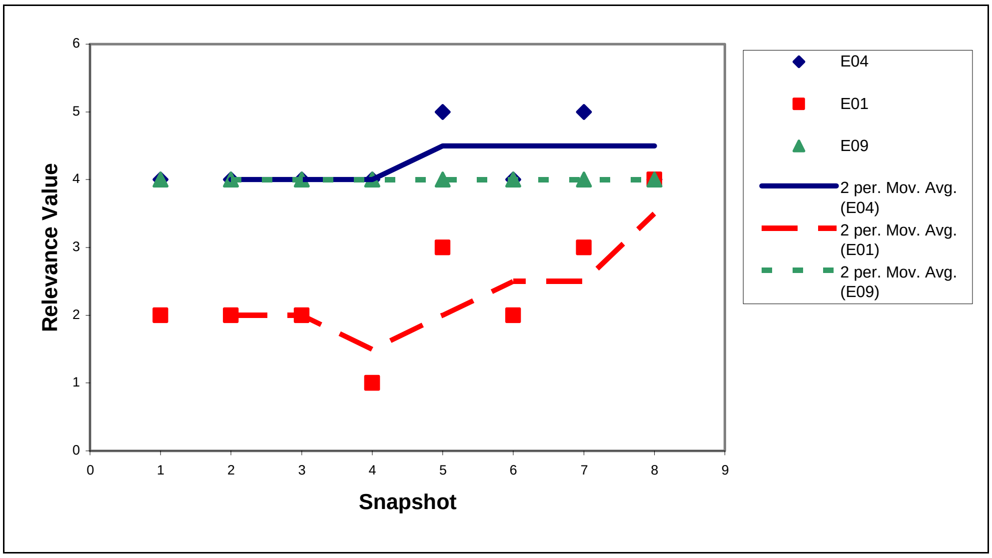


Figure I.2.6: Plots of relevance value towards content of 'Non-Learners' in the second play

# I.3 Plots of Cognitive Curiosity Value of 'Non-Learners'

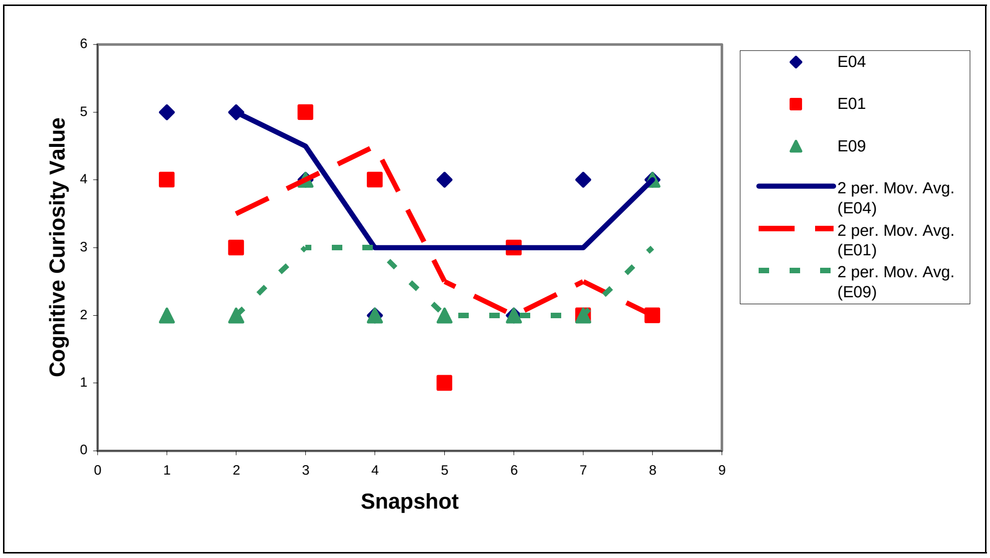


Figure I.3.1: Plots of cognitive curiosity value of 'Non-Learners' in the first play

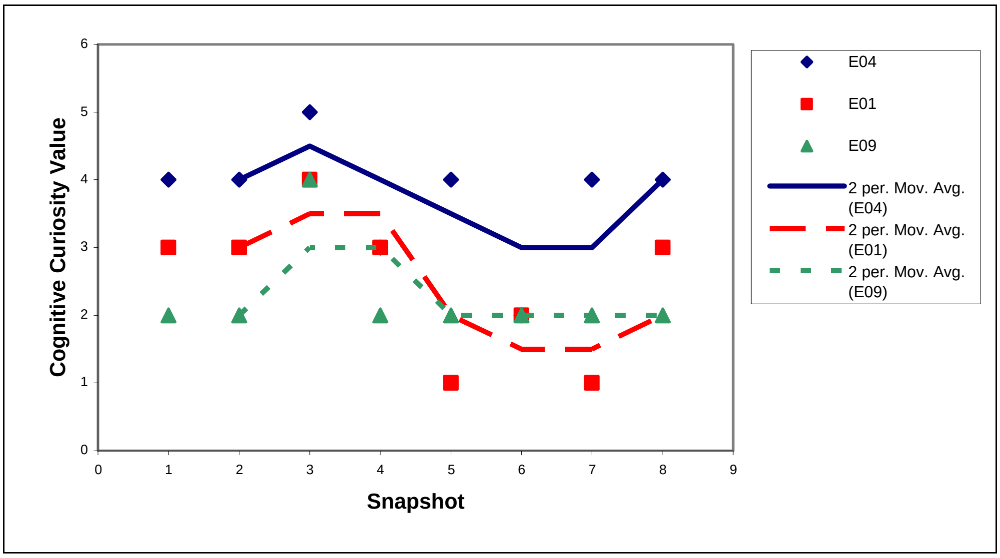


Figure I.3.2: Plots of cognitive curiosity value of 'Non-Learners' in the second play

# I.4 Plots of Effort Value of ‘Non-Learners’

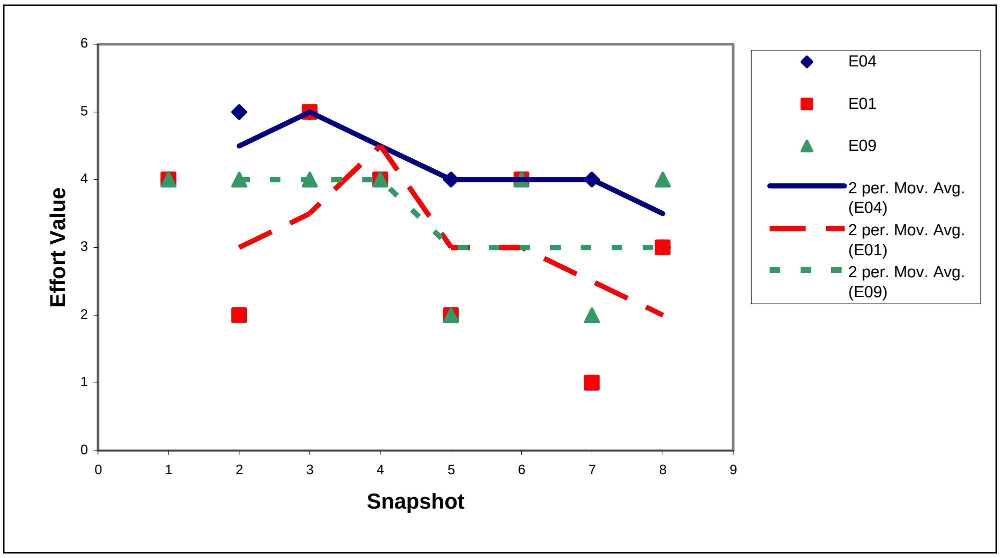


Figure I.4.1:   Plots of effort value of ‘Non-Learners’ in the first play

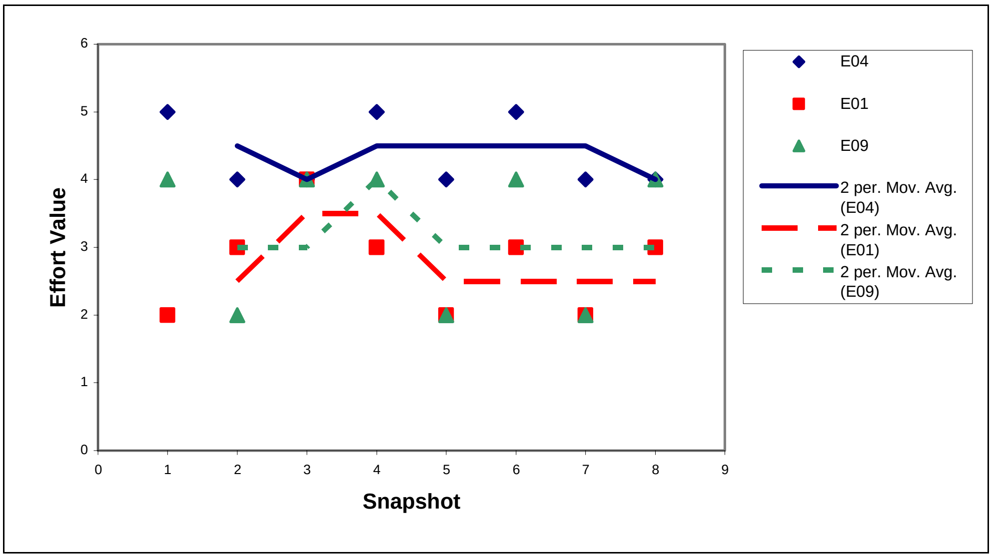


Figure I.4.2:   Plots of effort value of ‘Non-Learners’ in the second play

# I.5 Plots of Confidence Value of 'Non-Learners'

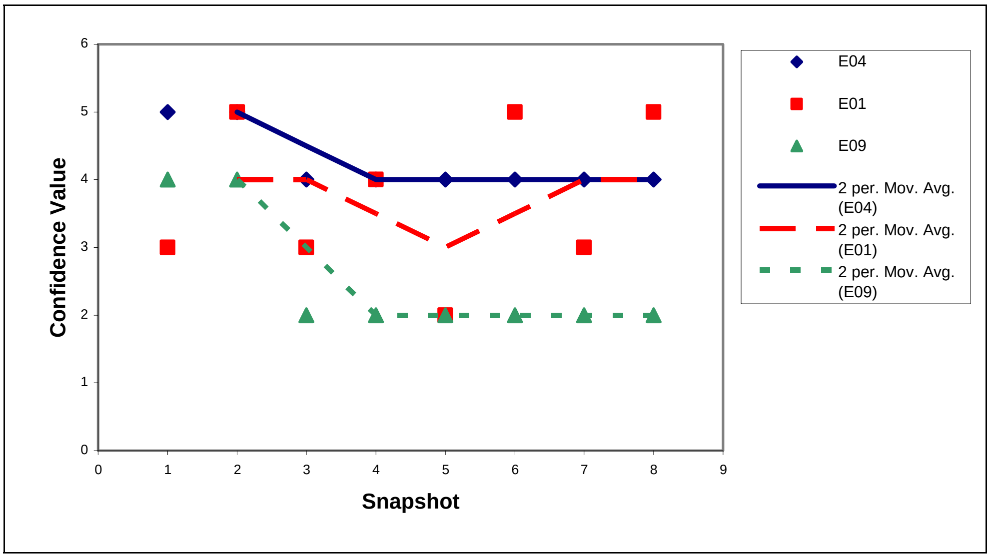


Figure I.5.1: Plots of confidence value of 'Non-Learners' in the first play

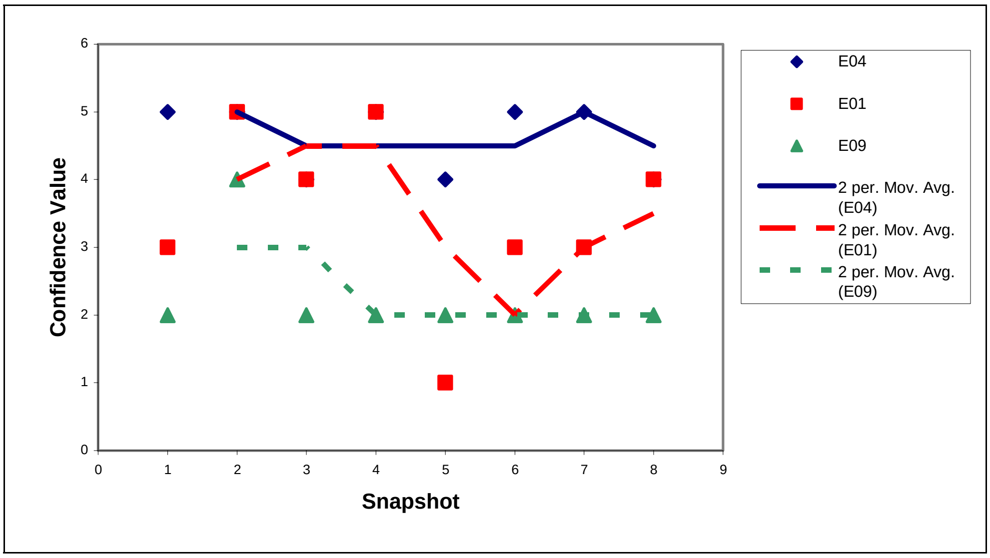


Figure I.5.2: Plots of confidence value of 'Non-Learners' in the second play

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